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Examining the Role of Green IT/IS Innovation in Collaborative Enterprise-Implications in an Emerging Economy

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Abstract
Sustainability is a significant field in both research and practice as such Collaborative Enterprise (CE) are adopting sustainable initiatives to achieve efficient resource usage, CO_2 emissions reduction, energy utilization reduction, moderate cost incurred, ethical waste management and natural resources conservation. Therefore, this research develops a model based on diffusion of innovation theory and sustainable life cycle process identified through literature review after which survey method was employed. The survey questionnaire was distributed targeting IT practitioners and IT managers of CE based in Malaysia. With 133 valid questionnaires in hand, the collected data were analysed using Statistical Package for Social Science (SPSS). Results reveal that the internal and external characteristics influences enterprise sustainability innovativeness. Furthermore, results confirm the identified sustainable life cycle process derived from the literature. Findings from this study support policy makers in CE understand and develop process towards sustainability attainment. By applying the developed model, CE can strategize their current process towards improving the sustainability of their enterprise.

Keywords: Society; Sustainability; Green IT/IS innovation; Sustainable life cycle process; Diffusion of innovation theory; Collaborative enterprise.

1. Introduction

Collaborative enterprise (CE) involves the association of different enterprises working together to achieve a common goal (Jnr et al., 2020). CEs utilizes a system of communication among corporate practitioners that encompass the use of a collaboration platform, enterprise social networking tools, a corporate intranet and the public internet (Kim, 2008; Jnr, 2020). CE enables IT practitioner in organizations to share information with one another and work together on projects from different geographic locations through a combination of collaborative process (Tencati and Zsolnai, 2009; Jnr et al., 2020). Sustainability in enterprise is a significant field in both research and practice as such CE are initiating Green Information Technology and Information Systems (IT/IS) practices to address environmental, economic and societal issues towards achieving efficient resource usage, CO_2 emissions decrease, energy utilization reduction, and cost reduction (Loeser et al., 2017). CEs utilization of IT and IS to facilitate natural resource conservation for sustainability attainment has been termed as Green IT and Green IS. Green IT mainly addresses environmental issues associated with increasing energy utilization of deployed IT infrastructure and consequently lessening IT induced CO_2 emissions (Anthony et al., 2020).

But, over the years Green IT in CE has mostly focused on energy utilization of enterprise departmental offices and data centres (Deng and Ji, 2015), whereas Green IS aids environmental management systems towards the rejuvenation of organizational and production operations (Butler, 2011a; Kristoffersen et al., 2019). Green IS entails usage of innovative intelligent real time data to reduce environmental effects of enterprise operations in circular economy (Kristoffersen et al., 2019). A few researchers such as Molla (2009) considers performance targets and cost reduction as the main motivators behind Green IT adoption in CE such as IT based organizations and therefore perceives Green IT as the practice of increasing the proficient utilization of computing resources to lessen ecological impact. However, other academicians such as Watson et al. (2010) criticize this technology based approach of Green IT and suggested Green IS terminology by maintaining that the role of IT as an enabler for sustainability attainment (Green IT) within CE should be able to do more by considering an essential element (Green IS). Hence, researchers such as Jenkin et al. (2011); Zheng (2014); Dalvi-Esfahani et al. (2017a); Jnr et al. (2020) considers both Green IT and Green IS as Green IT/IS in their research on environmental sustainability of IT as a medium to diminish the negative effects and thereby increasing the positive effects of CE.

Green IT/IS innovation provides solutions that reduce resource waste and CO_2 emissions during the design of end users' services and products thus reducing environmental footprint of enterprise activities (Jnr et al., 2020). Green IT/IS innovation is concerned with the progressive environmental gains that can be attained by lessening the negative ecological impacts of enterprise operations towards corporate sustainability advancement (Butler, 2011a; Loeser et al., 2017). Green IT/IS innovation thereby reveals opportunities to diminish enterprise business operational consumption of natural resources thus addressing 2^{nd} order effects of IT deployment in collaborative enterprise (Watson et al., 2010; Ainin et al., 2016). Thus, Green IT/IS innovation emphasizes the role of system application as an enabler to resolve sustainability issues faced by economies (Ainin et al., 2016). Real life examples of Green IT/IS innovation in CE involves utilizing IS technologies to efficiently support enterprise in reducing energy usage, electronic waste (e-waste) reduction, cost decrease of IT operation, Greenhouse gas reduction etc. Besides, Green IT/IS innovation in CE lessen the harmful environmental impact of CE manufacturing, transportation, usage and disposal of IT infrastructure, and equipment (Anthony Jr, 2020).

But currently CE predominantly focus on implementing conventional Green IT practices such as Green sourcing for hardware and deploying energy efficient equipment, since the decrease of power utilization is usually associated to cost savings (Karanasios et al., 2010). According to Anthony Jr et al. (2018) enterprises claim they adopt Green IT/IS by only implementing recycling operation and ignoring other sustainable life cycle process. This is mainly due to the prospect that recycling concept is synonymous with sustainable practices. Consequently, Anthony Jnr (2019) mentioned that there is need to provide the sustainable life cycle process to be implemented by IT practitioners in CE based on a comprehensive model. Similarly, prior Green IT/IS models offer little practical guidelines on sustainable life cycle process to be deployed in enterprise current operations (Butler, 2011b; Jenkin et al., 2011). Besides, there are internal and external variables that influence Green IT/IS innovation in CE. Hence, there is a need for a model that can be utilized by CE to ensure that IT practitioners considers these variables when adopting Green IT/IS innovation in their enterprise.

Therefore, the aim of this paper is to identify the constructs that influences Green IT/IS innovation in CE by answering the following research questions:

- What are the internal and external characteristics that influence Green IT/IS innovation in CE?

- What are the sustainable life cycle process that enable enterprise to implement Green IT/IS innovation in CE?

To answer the research questions, this study derived the internal and external characteristics through the integration of Diffusion of Innovation (DoI) theory, and sustainable life cycle process from the literature. Then, a research model is developed and validated using survey data and analysed by employing Statistical Package for Social Science (SPSS) version 23 for explorative, descriptive, and inferential analysis. The organization of this paper is as follows. The conceptual background of the study is presented in Section 2. The research model and hypotheses development are discussed in section 3. Research methodology has been presented in section 4. The results of the survey are presented in section 5. Section 6 presents the discussion. Section 7 discusses the implications of the study. Lastly, conclusions, limitations and future works are presented in section 8.

2. Conceptual Background

2.1. Overview of Collaborative Enterprise

Collaborative enterprise is coined from the term collaboration, which refers to an association that encompasses two or more businesses, working cooperatively towards achieving a shared goal towards the organizations mission (Jnr et al., 2020). Figure 1 depicts an overview of CE showing how individual, internal, and external characteristics influence CE operations. Moreover, Figure 1 shows how enterprises collaborate in creating competitive advantage to end users and stakeholder.

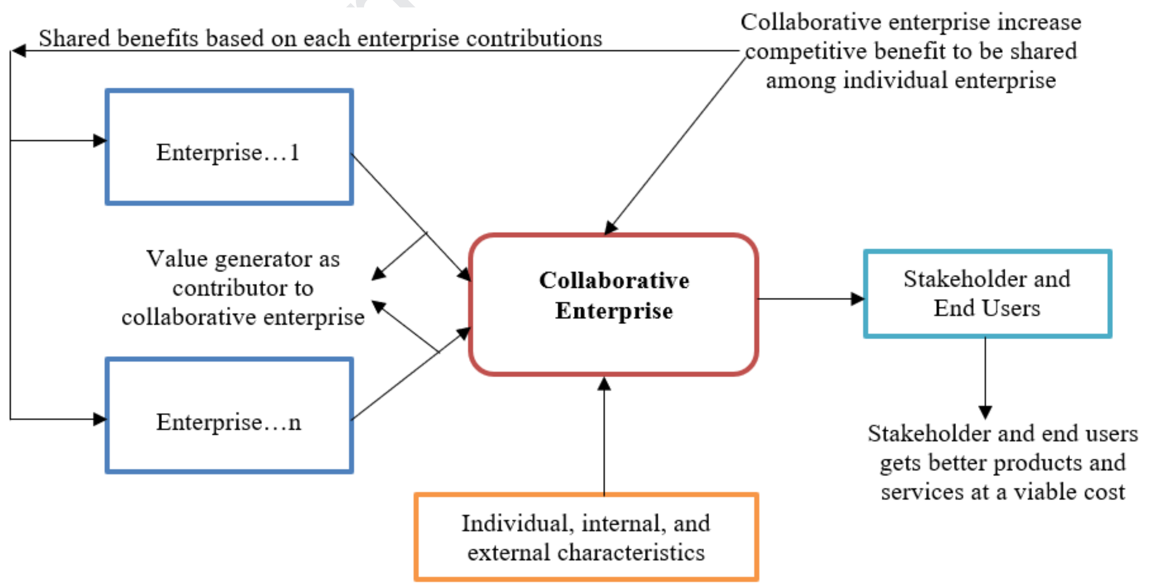

Figure 1 Overview of collaborative enterprise

Nowadays, CE carryout their organizational operations by deploying and utilizing resources that are facilitated by IT infrastructures (Vela et al., 2007) which consumes electricity thereby emitting CO_2 to the atmosphere that contributes to climatic changes, global warming and environmental degradation. Due to these environmental issues CE are implementing Green IT/IS innovations in attempting to address environmental, economic and societal issues towards achieving efficient natural resource conservation, cost saving decrease, energy efficiency, eco-friendly waste management, and CO_2 emission reduction (Loeser, et al., 2017). Accordingly, there is need for a Green IT/IS model to support CE in assesing their current Green IT/IS innovation in attaining economic, social and environmental sustainability towards a Greener society for future generations to come. Although, Green IT/IS research has been investigated by prior studies in traditional organizations such as in IT based firms (Molla et al., 2014), banking industries (Sahu and Singh, 2016) etc. there are limited works that has been directed to CE based domain. Similarly, over the years there has been pressure from governmental and non-governmental organization, stakeholders and end users for CE to implement Green IT/IS innovation.

2.2. Impacts of IT on the Natural Environment

This sub-section presents a practical and theoretical understanding of the effect of IT usage in CE. The effect of IT as shown in Figure 2 comprise of first, second and third order effects, where the environmental effects of IT differ considerably depending on the enterprise sector, for instance in manufacturing based enterprise, the first order impact is only 2 percent, whereas the second order effect amounts to about 60 percent, and lastly the third order impact of IT is more than 30 percent as mentioned by Berkhout and Hertin (2001). In other enterprises such as firms that deploy IT, the impacts are totally different. Where, the first order impact amounts for nearly 70 percent and the second order impact is almost 29 percent, whereas, the third order impact amounts to only 1 percent (Berkhout and Hertin, 2001). The relationship of IT usage and the natural environment can be presented into three categories namely; first order (direct impacts), second order (enabling impacts), and third order (systemic impacts) as seen in Figure 2.

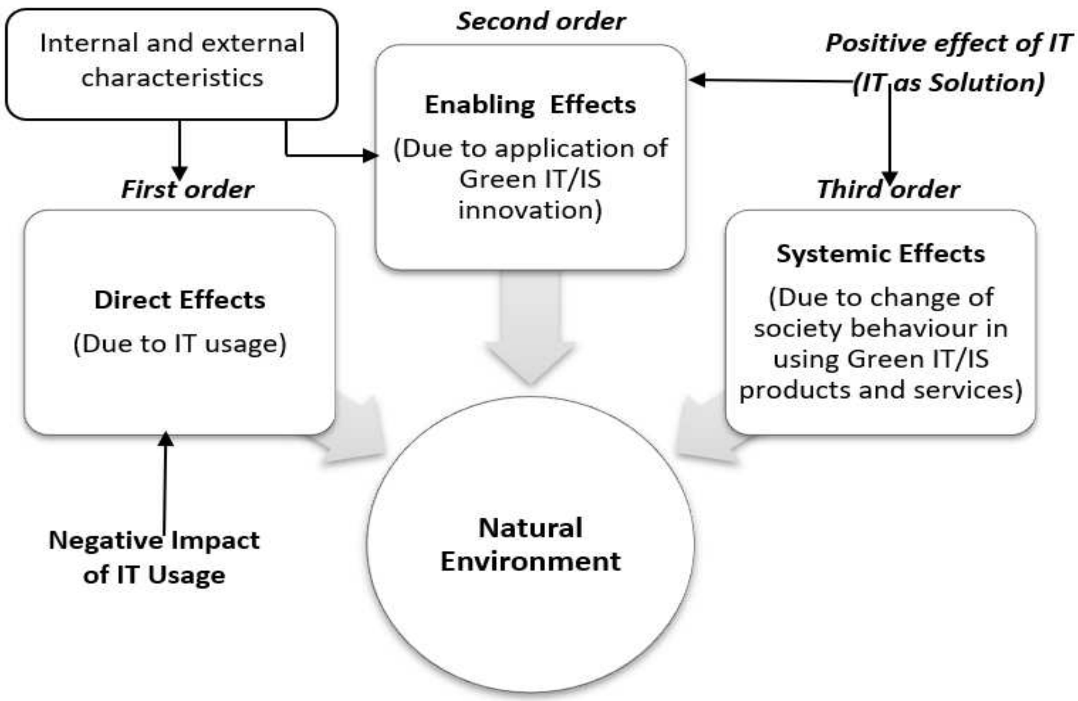

Figure 2 Effects of IT on the natural environment adopted from (Anthony et al., 2020).

Figure 2 depicts the impact of IT deployment and usage on the natural environment outlining the direct impact (first order) environmental impact of IT which relates to energy consumption of enterprise data centers that result to CO_2 emission and disposal of obsolete IT infrastructures (Anthony et al., 2020). The first order environmental effect of IT defines the direct negative impacts that are generated through the deployment, design, and disposal of IT equipment (Mickoleit, 2010). It consists of raw materials used for the manufacture of IT related hardware, electricity generation generated through renewable resource, and other numerous negative effects that arise through e-waste. The first order involves environmental issues (caused by IT) that are resolved by Green IT/IS and includes the running of enterprise data centers, IT equipment use, IT sourcing, and IT disposal (Erek et al., 2012).

The enabling impact (second order) refers to the impact that Green IT/IS can have on the enterprise internal operations (Anthony et al., 2020). Hence, the enabling impact of IT (second order) arises from deployment of IT systems and IS applications that lessen environmental effects across social and economic activities (Loeser et al., 2017). The enabling impact influences how enterprise produce, consumed and dispose of materials, thus making natural resources consumption and production more efficient (Mickoleit, 2010). Moreover, Figure 2 shows that both the first and second order impact from CEs are influenced by internal and external characteristics determined by CE`s operations. Next is the systemic impact (third order) which relates to environmental impact caused by utilizing developed IT products and services (Anthony et al., 2020). The third order-environmental effects summarize the impacts that arise when end users (society) uses IT (Erek et al., 2012). Conversely, the third order impact is only pertinent for enterprise where IT is mainly utilized as part of the end product, where the impact ranges from service that decreasing the quantity of negative environmental impacts through the utilization of IT such as online banking, which lessens paper consumption and CO_2 emissions (Mickoleit, 2010).

2.3. Theoretical Foundation

Several frameworks, model and theories as seen in Table 1 have been employed to examine the factors that influences Green IT/IS innovation in enterprises.

Table 1 Prior theories, models and frameworks applied in Green IT and Green IS research

Theories, models and frameworks	Description and Key Constructs	Sources
Theory of Reasoned Action (TRA)	TRA provides the basic conceptual theory for investigating the behaviour of humans. The TRA model involves four constructs which comprises attitude towards behaviour, subjective norms, behavioural intention, and actual behaviour (Ajzen and Fishbein, 1980).	(Sarkar and Young, 2009; Mishra et al., 2014).
Theory of Planned Behaviour (TPB)	TPB is a conceptual model proposed to further extend the theory of reasoned action. TPB constructs includes attitude towards behaviour, subjective norms, perceived behavioural control, intention to use, and behaviour (Ajzen, 1991).	(Akman and Mishra, 2014; Dezdar, 2017).
Technology Acceptance Model (TAM)	TAM was developed by Davis in 1989 and is adopted to predict and understand the process of user acceptance or adoption of IS. TAM conceives that perceived usefulness and perceived ease-of-use can influence ones' attitude to adopt a given technology. Moreover, the attitude-towards-use can predicts the behavioural intention to use and, intention determines the actual use (Davis, 1989).	(Schmidt et al., 2010; Akman and Mishra, 2015).
G-readiness theory	The G-readiness theory was conceptualized based on the extension of Molla and Licker (2005)'s e-readiness model with literature on Green IT towards achieving a sustainable business practice in enterprise (Molla et al., 2011). The theory comprises of creation, sourcing, usage and end of life.	(Molla et al., 2011; Jnr et al., 2020)
Norm activation model (NAM)	NAM was established by Schwartz (1974) in human behaviour domain and has been applied to examine pro-social behaviour. NAM constructs comprise of exploring individuals' pro-social behaviour which includes personal norms, ascription of responsibility and awareness of consequences.	(Lei and Ngai, 2014; Dalvi-Esfahani et al., 2017b).

Upper echelon theory (UET)	UET was proposed by Hambrick and Mason (1984) in behavioural theory of an organization. The underlying constructs of UET is that managers strategic environmental behaviour is based on their personal experiences, values, and personalities (Hambrick, 2007).	(Dalvi-Esfahani et al., 2017a).
Resource Based View (RBV)	RBV was proposed by Wernerfelt (1984) to explain the competitive advantage of enterprise. Enterprise resources can be thus categorized into three capital resources constructs namely physical, organizational, and human (Barney, 1991).	(Rahim and Rahman, 2013; Simmonds and Bhattacherjee, 2014; Deng and Ji, 2015).
Natural Resource Based View (NRBV)	Hart (1995) proposed the NRBV by incorporating the natural environment into RBV. NRBV comprises of pollution prevention, product stewardship and sustainable development as key constructs.	(Chen et al., 2011; Rahim and Rahman, 2013).
Motivational theory	This theory described the motives behind enterprise' views and actions of organizations in which behaviour is determined by human motivational factors (Molla and Abareshi, 2012). The motivation theory comprises of three constructs motives, and they include competitiveness, legitimation, and social responsibility.	(Molla and Abareshi, 2011; Molla and Abareshi, 2012).
Institutional theory (INT)	INT aimed to investigate how organizations become influenced under social pressures, external pressure, other times internal pressure from within the firm (DiMaggio and Powell, 1983). Institutional theory is conceptualized through three constructs namely normative, mimetic, and coercive isomorphism.	(Sarkar and Young, 2009; Butler, 2011a; Chen et al., 2011; Lei and Ngai, 2012).
Technology-organization-environment framework (TOE)	TOE framework was proposed by Tornatzky et al. (1990) from Rogers's (1995) diffusion of innovation theory by adding the environmental context as a new variable to the existing technology and organisations variable suggested by Rogers. TOE provides a generic model that employs the organizational, technological and environmental determinants to investigate factors that could affect diffusion of IT/IS in organizations.	(Molla, 2008; Bose and Luo, 2011; Nedbal et al., 2011; Cooper and Molla, 2014; Zheng, 2014; Anthony Jr, 2020).
Process-virtualization-theory (PVT)	PVT was founded by Overby (2008) to offer a conceptual theory for examining variables that influences the virtualizability of Green IT implementation in enterprises. PVT constructs include process virtualizability, synchronism requirements, sensory requirement, identification and control requirements, and relationship requirements.	(Bose and Luo, 2011; Nedbal et al., 2011; Jnr et al., 2020).
Diffusion of Innovation (DoI) theory	DoI theory was proposed by Rogers (1995) to offers in depth description on how novel innovations are diffused, and how adoption decisions are influences by usage of the technology itself as well as the characteristics of the adopting firms and their related environment. DoI theory constructs comprises of external characteristics of the organization, organizational innovativeness, internal characteristics of organizational structure, and individual (leader) characteristics.	(Schmidt et al., 2010; Bose and Luo, 2011; Nedbal et al., 2011; Cai et al., 2013).
Organizational information processing (OIP) theory	The OIP theory was suggested by Galbraith (1974) by identifying information processing necessity, information processing ability as the independent variables and information processing performance as dependent variable.	(Lei and Ngai, 2012).
Belief-Action-Outcome (BAO) framework	BAO framework was proposed by Melville (2010) who derived the framework from Coleman's (1986) micro-macro-model to develop links between the determinants of social and managerial environmental contexts on individuals' beliefs about the natural environment and the impact of their beliefs on environmental actions and subsequent outcomes.	(Melville, 2010; Gholami et al., 2013; Molla et al., 2014; Recker, 2016; Loeser et al., 2017; Anthony Jr, 2019).

Table 1 describes theories and related constructs previously employed in prior Green IT and Green IS studies. The review from Table 1 reveals that different theories have been adopted to examine variables or factors that influence Green IT and Green IS initiatives. While, the reviewed theories such as TOE, BAO, etc. are valuable in understanding variables that influence Green IT/IS innovation, they are less applicable in assessing different phases of innovation and explaining the sustainable life cycle process to be deployed. Respectively, in choosing the theories for this study, the author sought a theory that can help in examining the variables that influence Green IT/IS innovation, and further explore the outcomes of sustainable life cycle process. To this end, it was found that DoI theory was suitable for this purpose, since its more concerned about technological deployment. Thus, DoI is employed as it helps to assess the impact of Green IT/IS innovation. Respectively, this study opted for DoI theory in conceptualizing the research model which is developed based on identified sustainable life cycle process and variables that influence Green IT/IS innovation in CE. A description of DoI theory is presented below.

2.3.1. Diffusion of Innovation (DoI) Theory

Diffusion of innovation (DoI) theory was proposed by Rogers in 1995 to provide detailed descriptions of how novel innovations are implemented, and how diffusion decisions are influenced based on technology being utilized in relation to features of the adopting firm and associated environment. According to Rogers (1995) diffusion is the process by which an innovation is conversed between members of a social system (Deng and Ji, 2015). Accordingly, DoI theory describes how, why and at what speed innovations disseminates through enterprise and individual level (Oliveira and Martins, 2011).

Practitioners are having different opinion regarding their readiness to adopt innovations; thus, it is usually observed that the percentage of people who utilize an innovation is usually dispersed over time (Rogers, 1995). Thus, in an organizational context, the innovation diffusion process is much more multifaceted and normally comprises several practitioners, which includes both opponents and supporters of innovation such as Green IT/IS, each of whom contributed to decision making regarding the innovation. Based on DoI theory at enterprise level, the innovativeness is determined by variables such as external characteristics of the firm, internal firm structural characteristics, and individual (leader) characteristics as shown in Figure 3.

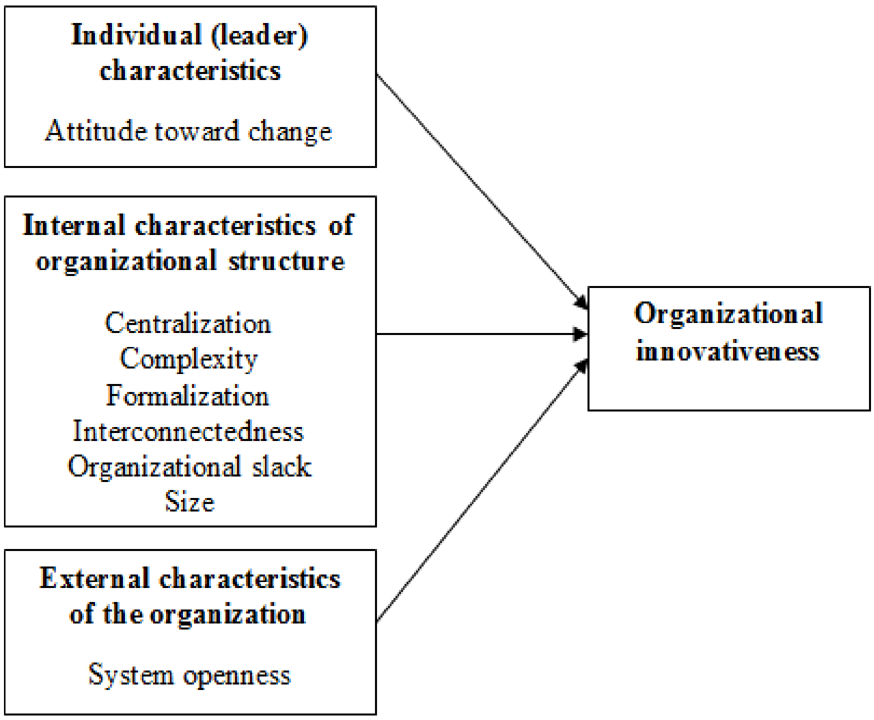

Figure 3 Diffusion of innovations theory adapted from (Rogers, 1995)

Figure 3 depicts the DoI theory as developed by Rogers (1995). The theory comprises of individual (leader) characteristics, internal characteristics of organizational structure, and external characteristics of the organization as the main constructs that influences organizational innovativeness which is the dependent variable. As described by Oliveira and Martins (2011), each of the main constructs attributes is described below;

- The individual determinants designate the management attitude toward change, where the internal determinants of organizational structure include observations.
- Centralization refers to the point where control and power in the organization are leveraged for the control of management committee members.
- Complexity is associated with the degree to which enterprise staffs have a comparatively high level of expertise and knowledge.
- Formalization refers to emphasizes enterprise placed on its staffs to implement certain regulation and rules.
- Interconnectedness refers to which divisions in the enterprise system are linked by inter-personal networks.
- Organizational slack entails to which extent uncommitted human resources are available within the enterprise.
- Size entails the actual number of staffs both full time and contract employees in the enterprise.
- External characteristics in the enterprise refer to the openness of the organizational system.

DoI theory has been adopted across domains, especially in IT adoption studies by investigating how new systems and technologies are employed and how deployment decisions are influenced by the opinions of new technologies (Bose and Luo, 2011). This current study opted for DoI theory because its lays a theoretical foundation for prior technology innovation adoption studies (Oliveira and Martins, 2011) among others DoI is based on examining factors that influences technology innovation adoption decisions. DoI theory has be adopted in previous Green IT and Green IS research by Schmidt et al. (2010); Bose and Luo (2011); Nedbal et al. (2011); Cai et al. (2013) respectively. Although, DoI theory has been criticized for being more concern to the technological construct in the adoption process (Oliveira and Martins, 2011). Researchers such as Bose and Luo (2011); Deng and Ji (2015) argued that DoI theory is a robust theory, strong in its descriptive effect.

In this study Green IT/IS innovation is conceptualized based on DoI theory to links the internal and external characteristics as independent variables and organizational as dependent variable only. The individual characteristics is considered out of the scope of this current study. The internal and external characteristics comprises of human resources, IT governance, technological integration, competitive strategy, information intensity and regulatory environment, whereas the dependent variable comprises of the Green IT/IS innovation which is being assessed. Moreover, the dependent variable Green IT/IS innovation is based on the current sustainable lifecycle process being implemented in CE derived from the literature which comprises of Green creation, Green distribution, Green sourcing, Green operations, and end of life (Ninlawan et al., 2010; Raza et al., 2012; Saha, 2014; Anthony et al., 2020; Jnr et al., 2020). Therefore, the research model that shows all the extended relationships are presented in Figure 4.

3. Research Model and Hypotheses Development

3.1. Internal and External Characteristics (Independent Variables)

This sub-section addresses the first research question; what are the internal and external characteristics that influence Green IT/IS innovation in CE? The identified internal and external characteristics (human resources, IT governance, technological integration, competitive strategy, information intensity and regulatory environment) are discussed below;

3.1.1. Human Resources

Human resources are the employees that possess the skills and knowledge to adopt Green IT/IS innovation (Deng and Ji, 2015; Anthony et al., 2020). This variable encompasses the employees, professionals and experts involved in enterprise operation. In organizational context human resources refers to the number of staffs in a firm (Sahu and Singh, 2016). Where, the employees' attitude towards the environment will affect the innovation of Green IT/IS (Li et al., 2019; Jnr et al., 2020). So, it is important to empower staffs by developing their expertise through training on sustainability, hence that they can utilize the knowledge and skills obtained to champion sustainability goals (Ainin et al., 2016; Dalvi-Esfahani et al., 2017b; Loeser et al., 2017). Thus, personnel in CE should not be a means to only acquire profit but need also emphasis on the wellbeing of the employees. Thus, it is proposed that:

H1: Human resources behaviour will positively influence his/her action toward Green IT/IS innovation in CE.

3.1.2. IT Governance

IT governance comprises the managerial regulation and rules that administrates the enterprise daily operations (Deng and Ji, 2015; Jnr at al., 2020). IT governance entails policies that support CE decision making (Bekhet and Latif, 2018). These polices are procedures to govern Green IT/IS innovation aimed at facilitating environmental practices (Zheng, 2014). Hence, IT governance policies increases firms' responsiveness on issues pertaining to environmental governance at corporate level (Jnr et al., 2020) and provide an agenda for employee in the organization to achieve sustainability (Butler, 2011a). This variable incorporates the commitment and support of management towards enterprise diffusion of Green IT/IS innovation for sustainability attainment (Dalvi-Esfahani et al., 2017a). Therefore, it is proposed that:

H2: IT governance structure will have a positive effect on the Green IT/IS innovation in CE.

3.1.3. Technological Integration

Technological integration consists of both IT infrastructures such as networks, database servers, application and equipment utilized by staffs to accomplish the aim and objectives of the firm (Anthony et al., 2020). Hence, enterprise acquiring, deploying eco-friendly technologies and systems can facilitate the attainment of sustainability (Karanasios et al., 2010; Jnr et al., 2020). This characteristic also explores the technical perspective that influences Green IT/IS innovation (Tariq et al., 2017). Moreover, these technologies also contribute to environmental pollution and can also be a possible solution to environmental pollution (Akman and Mishra, 2014). Likewise, renewable energy technologies generated from solar, wind, etc. can be employed as a substitute to replace coal-fired energy stations that delivers electricity, since coal emits carbon emissions which contributes to global warming (Deng and Ji, 2015; Mishra et al., 2014). Thus, it is proposed that:

H3: Green IT/IS innovation is significantly influenced by the intensity of technologies deployed in CE.

3.1.4. Competitive Strategy

The strategy entails procedures and activities deployed in the firm (Karanasios et al., 2010). Competitive strategy is an important element that influence business development and supports the innovativeness of the organization to diffuse Green IT/IS innovation towards achieving long term ecological, society and economic advantages (Jenkin et al., 2011). The strategies infused may include supporting enterprise reduce operational cost, minimize carbon emissions thereby changing the direction towards realizing sustainability goal (Molla et al., 2008). This variable also involves characteristics of the enterprise in term of its scope and operations carried out in the organization towards Green IT/IS innovation (Jnr et al., 2020). Additionally, competitive strategy facilitates businesses reduce operating costs in development (Ainin et al., 2016). Therefore, competitive strategies can be established with activities to promote Green IT/IS awareness on the cause of environmental problems and how to promote sustainable practices. Based on the above, the following hypothesis is presented:

H4: The competitive strategy employed in CE positively influences Green IT/IS innovation.

3.1.5. Information Intensity

Information intensity regarding Green IT/IS innovation entails the provision of knowledge source on how businesses can improve Green IT/IS innovation (Watson et al., 2010; Butler, 2011b). Accordingly, the intensity of information available in CE can assist in diminishing energy depletion (Jnr et al., 2020), which is one of the objective of Green IT/IS innovation as there is a positive profit that can be achieved with the utilization of less energy which leads to the decrease of CO_2 released through organization operations (Boudreau et al., 2008; Hasan et al., 2012). Thus, it is proposed that:

H5: The intensity of information in CE significantly influences Green IT/IS innovation.

3.1.6. Regulatory Environment

This characteristic mainly comprises internal and external pressure that motivates enterprise decision towards Green IT/IS innovation (Lintukangas et al., 2016). Businesses are influenced to adopt Green IT/IS innovation due to high cost of energy that is required in running enterprise operation (Howard and Lubbe, 2012). Furthermore, CE are imposed by governmental bodies and non-governmental organizations (NGOs) to diffuse Green IT/IS innovation by imposing ecological regulations (Karanasios et al., 2010; Vykoukal et al., 2011). Similarly, social pressure from consumers and stakeholders also influence firm's mission to diffuse Green IT/IS innovation (Jenkin et al., 2011; Ainin et al., 2016). Consequently, businesses are persuaded by increased societal request for eco-friendly products and evolving community indulgent of Green goods and services (Jnr et al., 2020). Thus, it is proposed that:

H6: Environmental regulations and laws set by NGOs and governmental associations will significantly influence Green IT/IS innovation in CE.

3.2. Sustainable Life Cycle Process for Green IT/IS Innovation

This sub-section aims to address the second research question; What are the sustainable life cycle process that enable enterprise to implement Green IT/IS innovation in CE? The derived sustainable life cycle process comprises of Green creation, Green sourcing, Green usage, end of life, and Green distribution.

3.2.1. Green Creation

Green creation aims to evaluate, design and produce Green products with low side effect on the environment (Jnr et al., 2020). CE typically marginalized environmental impact during manufacturing operation; hence harmful wastes are disposed-off without considering the environmental effect (Murugesan, 2008; Ninlawan et al., 2010). Therefore, issues regarding Green creation require modifying current design which is mostly difficult due to several incompatible objectives and high demand which entails high cost effectiveness and operating speed of data servers (Molla et al., 2009). Green creation in CE should address deploying only energy efficient appliances, connection of voltage stabilizers to servers and other computer related facilities (Jnr, 2020). Thus, it is proposed that;

H7: The current Green IT/IS innovation will have a positive effect on Green creation.

3.2.2. Green Distribution

This life cycle process involves steps taken toward implementing eco-friendly delivery strategies by changing enterprise activities to more proficient operations and enhancing the reusability and reutilizing rate of current IT infrastructures deployed within the enterprise (Raza et al., 2012). Green distribution initiatives include sterilized distribution outlines to encourage negligible waste produced, which improves the effectiveness of firm's data centres thereby decreasing energy, water and CO_2 released (Ninlawan et al., 2010). Green distribution facilitates costs reduction required through consumption of lesser energy and improved operating control (Saha, 2014). Hence, for enterprise to fully implement Green distribution every component required in deploying CE process should result to low or reduced effect on the environment (Jnr, 2020). Thus, it is proposed that;

H8: The current Green IT/IS innovation will have a positive effect on Green distribution.

3.2.3. Green Sourcing

CE can move towards Green sourcing by procuring electronic products that have labels such as, TCO 95 from Environmental Protection agency (EPA) Sweden, Blue Angel from Germany and Energy Star US (Karanasios et al., 2010). This lifecycle process also requires enterprise to deploy only equipment and infrastructures with eco-friendly labels, since such equipment utilizes less electricity thereby emitting lesser CO_2 emission to the natural environment. In Green sourcing, enterprise can also apply eco-friendly purchasing practice that includes reduction, buying of reused and recycled IT infrastructures in procuring services (Raza et al., 2012). Hence, it is required for business to apply ecologically preferable sourcing governance and Green procurement recommendations when purchasing IT infrastructures (Anthony et al., 2020). Thus, it is proposed that;

H9: The current Green IT/IS innovation will have a positive effect on Green sourcing.

3.2.4. Green Usage

This practice aims to save electricity which leads to less emission of Greenhouse gas emitted to the stratosphere when enterprise network and database servers are being utilized to facilitate organization's practitioners (Karanasios et al., 2010). Moreover, Green usage refers to environmental considerations in operating IT infrastructure in CE (Pichetpongsa and Campeanu, 2011). Green usage also aims to improve responsible energy usage in organization towards lessening power utilization of powering and cooling of enterprise IT facilities, improving power performance of data centres (Jnr et al., 2020). It also involves decreasing CO_2 emissions in data centers, achieving low carbon emitting business practices and lastly evaluating total ecological footprint of organizations (Raza et al., 2012). Based on the above, the following hypothesis is presented;

H10: The current Green IT/IS innovation will have a positive effect on Green usage.

3.2.5. End of Life

End of life provides businesses with a flexible audit strategy for collecting, re-processing and recycling of discarded out-dated IT hardware wastes (Murugesan, 2008). End of life involves Green disposal and recycling that helps to actively reduce waste, diminish CO_2 emissions and also decreases handling costs incurred in disposal IT generated wastes in landfills (Anthony et al., 2020), providing a medium to generate income return since disposed old IT hardware may still be useful and as such can be renovated and restored to be used in other enterprises (Raza et al., 2012). Hence, CE plans to reuse and refurbish old hardware components, while other unwanted hardware parts can be organised for recycling procedures (Anthony Jr et al., 2018). Thus, it is proposed that;

H11: The current Green IT/IS innovation will have a positive effect on end of life.

The research model is developed as shown in Figure 4. The model considers the internal and external characteristics (independent variables) that influence Green IT/IS innovation (dependent variable) which is based on the current sustainable life cycle process.

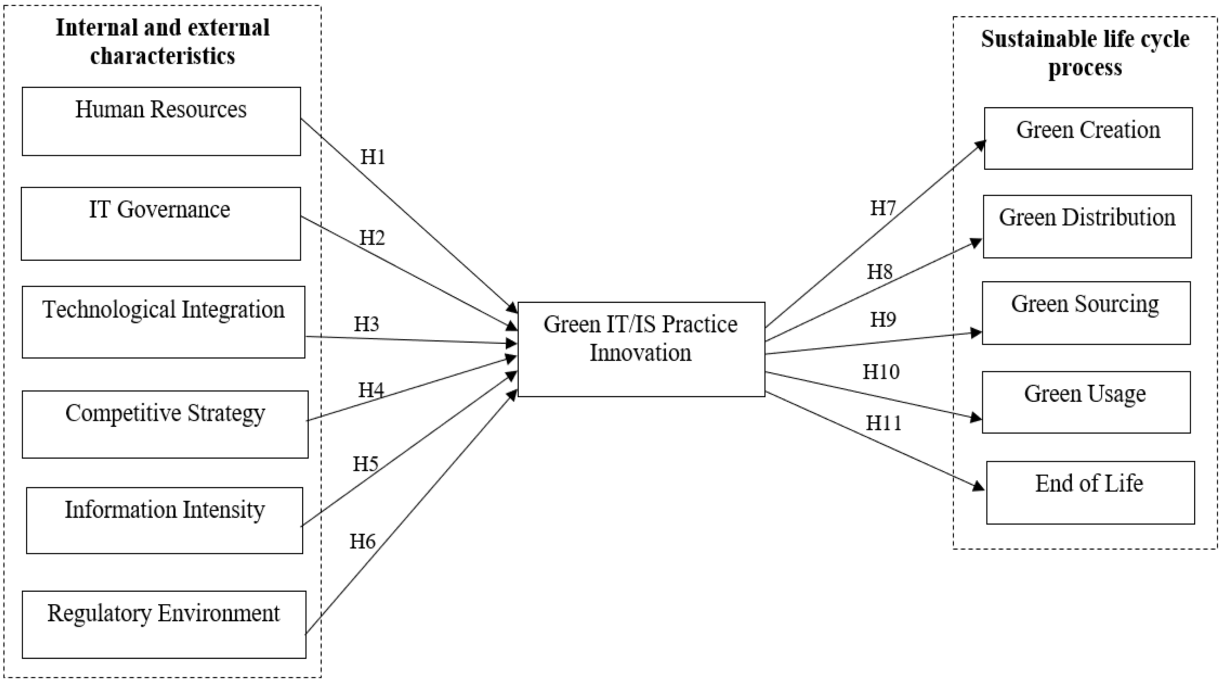

Figure 4 Research model

4. Research Methodology

4.1. Design

To evaluate the hypotheses in the developed research model, an online survey was designed targeting IT practitioners and IT managers as participants. This option was driven based on key conclusions from the literature, which includes the need for CE based research model centred on practice-oriented perceptions towards providing meaningful insights on Green IT/IS innovation. Malaysia is one of the countries committed to support sustainability by adhering to the guidelines such as that of ISO 14001 standards, thus Malaysia is selected as an appropriate research focus. Likewise, due to Malaysian government endorsements towards development of Green enterprise in the country, a few CEs have begun to implement eco-friendly practices to support in decreasing Greenhouse gas emission as promised by the former Prime Minister in the 2009 United Nations Climate Change Conference in Copenhagen Denmark. Thus, CEs in Malaysia are committed in reducing Green House Gases (GHGs) emission by 40 per cent per GDP by 2020 (Anthony Jnr et al., 2019).

Nowadays, CE in developing countries such as Malaysia carryout their organizational services by deploying and utilizing resources that are provided by IT infrastructures (Anthony et al., 2020) which consumes electricity thereby emitting CO_2 to the atmosphere that adds to climatic changes, global warming and environmental degradation (Jnr et al., 2020). Hence, there is need to deploy Green IT/IS innovation for cost saving reduction, increasing energy efficacy, ethical waste management, natural resource usage reduction and CO_2 emission decrease in CE for sustainability attainment towards social, economic and environment pursuit. Moreover, only a few studies such as Junior et al. (2018); Jnr (2020); Jnr et al. (2020) has explored eco-friendly practices in CE based in Malaysia, thus we opted to examine Green IT/IS innovation in CE based in Malaysia.

Additionally, the Malaysian context is particularly selected as the focus of this study rather than a developed country or any other developing country because IT practitioners in Malaysia CE are implementing Green IT/IS innovation to support environmentally friendly paradigms (Rahim and Rahman, 2013). Hence, IT practitioners in Malaysia CE are beginning to implement Green IT/IS innovation by adopting environmental management standards such as ISO 14001 and utilizing manual self-assessment methods based on checklists questionnaire (Junior et al., 2018). Due to this development, it is significant to investigate Malaysia CE to protect the environment and economic sustainability that characterize the goals for future developments (Molla and Abareshi, 2012; Jnr et al., 2020). Therefore, IT practitioners and IT managers in Malaysia CE are the target respondents as they possess in-depth knowledge towards Green IT/IS innovation in their enterprise, hence these respondents are selected using purposively sampling to represent the target population required to evaluate the research model.

Quantitative research was employed using online survey to collect data among IT practitioners to validate the developed model. Survey approach is a suitable tool for data collection in this study as it provides fast and easy means of collecting data. Moreover, survey instrument was employed in this study because of the benefits of reduced cost, no geographical limitations and fast response. Additionally, online surveys are suitable to validate model that hypothesizes the associations between constructs as presented in section 3.1 and 3.2. Hence, survey was employed to collect data from respondents. However, when collecting data using surveys issues such as low response rates, is a common setback, thus in designing the survey instrument, the recommendation proposed by Dillman (2007); Fowler (2009) was adopted as employed by Loeser et al. (2017); Anthony et al. (2020) in their research on Green IS initiatives.

4.2. Procedures and Measurement

The developed survey instrument was pre-tested by five domain experts who were familiar with Green IT/IS innovation to confirm the appropriateness of the measurement instrument. Feedback from the pre-test sessions helped to enhance the lexical structure, readability and understanding of the survey questions. After which the survey instrument was reviewed and updated by the experts, then it was set up online and access to the survey was sent through email together with a cover letter to participants that currently adopts Green IT/IS innovation in their organization. Participants selected based on their present role in their organization. To confirm each respondent is qualified to provide data required in validating the developed model hypotheses, each respondent’s details was confirmed through their enterprise Green center website. Email invitation messages were sent to experienced respondents to participate in the data collection at their own convenience.

In the survey questionnaire the respondent were given a brief overview about the research, why the data collection is important and a brief description of a few terminologies. The participants were also guaranteed of their anonymity. The first part of the questionnaire covers research overview. Then is the demographic data of the participants and their corresponding firm. Next, are questions to measure each of the constructs (see section 3.1 and 3.2) as seen in Table 2 and 3. Since the questionnaire was designed to validate the identified constructs the participants were requested to rate the significance of different items used to measure each construct in regards to Green IT/IS innovation in their respective organizations. Invitation to partake in the survey was first sent on January 2017, after which a second round of reminder was sent on February 2017, finally the last invitations was sent in March 2017 to expedite the reply rate together with an apology for many invitations sent.

More than 80 CEs which comprises of 1,190 respondents were invited to partake in the survey. To ensure that the samples are valid only respondents who implement Green IT/IS innovation were invited to partake in the survey. At the end, out of the 1,190 requests sent, a total of 133 responses were received. The sample is between medium ranges, hence acceptable based on similar sample utilized in prior Green IT/IS studies where Loeser et al. (2017) used data collected from 118 IT executives, Schmidt et al. (2011) employed 116 survey samples, Molla (2009) utilized 109 survey responses, Chen et al. (2011) used 75 survey responses, and Wati and Kuo (2012) used only 100 survey response in their study.

Table 2 Operationalization of internal and external characteristics and associated items

Internal and External Characteristics	**Code**	**Items to Measure Internal and External Characteristics**	**Citations**
Human Resources	HR1	Positive attitude of IT practitioners.	(Elliot and Binney, 2008; Molla et al., 2011; Anthony Jr, 2020).
	HR2	Ethical consideration of IT practitioners.	
	HR3	Social-culture of IT practitioners.	
	HR4	Overall competences of IT practitioners.	
	HR5	Opinions of IT practitioners in relation to the natural environment.	
	HR6	Awareness of IT practitioners in relation to the natural environment.	
	HR7	Experience of IT practitioners in the industry.	
	HR8	IT practitioners' intention to adopt eco-friendly initiatives.	
IT Governance	IG1	Official innovativeness structures.	(Hart, 1997; Murugesan, 2008; Molla et al., 2011).
	IG2	Executive involvement as an important role.	
	IG3	Executive moral support.	
	IG4	Executive exploration on approaches to decrease energy utilization.	
	IG5	Executive supports the use of IT hardware from Green IT suppliers.	
	IG6	Executive policy for the use of software to lessen e-wastes.	
	IG7	Executive policy on employee's usage of IT in an energy resourceful way.	
	IG8	Provides budgets and other monetary resources by executive.	
Technological Integration	TI1	Changing its business operation to be paperless.	(Info~Tech, 2007; Molla et al., 2011; Anthony et al., 2020).
	TI2	Deploy server consolidation and virtualization to lessen energy usage.	
	TI3	Utilize teleconferencing for meetings.	
	TI4	Deploy video conferencing within the organization.	
	TI5	Encourages telecommuting for conveying staffs around the firm.	
	TI6	Deploy online group chatting systems for enterprise daily operations.	
	TI7	Use of software to decrease enterprise wastes and emissions.	
	TI8	Use of software to diminish total use of harmful materials.	
Competitive Strategy	CS1	Address the carbon footprint of IT facilitated systems.	(Molla, 2009; Schulz, 2009; Molla and Cooper, 2014).
	CS2	Possess personal business strategy.	
	CS3	Provide economic returns from enterprise IT assets.	
	CS4	Employ strategies on how to attain ecological goals.	
	CS5	Deploy operational routines to simplify the presentation of acquired knowledge.	
	CS6	Refine measures to expedite newly assimilated knowledge.	
	CS7	Improve business prospects based on ecological perspective.	
Information Intensity	II1	Provides the up-to-date data relating to the environment within the organization.	(Butler, 2011b; Molla and Cooper, 2014).
	II2	Provide un-restricted access to information in the firm.	
	II3	Offers unique and detailed data within the firm.	
	II4	Providing similar and reliable data within the firm.	

Regulatory Environment	RE1	Influenced by government and NGOs rules and regulations in the firm.	(Butler, 2011b; Chen et al., 2011; Vykoukal et al., 2011).
	RE2	Executive involvement motivates Green IT/IS innovation.	
	RE3	Incentives provided by government influence Green IT/IS innovation.	
	RE4	Influence from other competitors influences Green IT/IS innovation.	
	RE5	Social pressure from consumer, stakeholder and dealers.	
	RE6	Motivation from external bodies.	
	RE7	Future outcome of firm actions	

Table 3 Operationalization of sustainable life cycle process and associated items

Sustainable Life Cycle Process	**Code**	**Items to Measure Sustainable Life Cycle Process**	**Sources**
Green Creation	GC1	Resolve electricity consumption of lighting and cooling in our organization.	(Accenture, 2008; Schmidt et al., 2009; Molla et al., 2011; Jnr et al., 2020).
	GC2	Interested about the effectiveness of running our firm IT systems.	
	GC3	Considers ecological elements in the design of our enterprise infrastructure.	
	GC4	Reposition our firms' data center to be close to renewable energy source.	
	GC5	Utilize energy from Green power providers in our firm.	
	GC6	Imposes electricity management in our organization.	
Green Sourcing	GS1	Deploy applications to make raw material purchasing eco-friendlier.	(Accenture, 2008; Velte et al., 2008; Schmidt et al., 2009; Jnr et al., 2020).
	GS2	Buys recycled hardware equipment for enterprise use.	
	GS3	Buy IT hardware from vendors with Green licenses and certifications.	
	GS4	Consider ecological factors when we procure IT hardware in our firm.	
	GS5	Install eco-friendly procurement policy.	
	GS6	Buy IT equipment from merchants that provides take back preference.	
Green Usage	GU1	Employ ecological concern in planning IT operations.	(Velte et al., 2008; CFO, 2009; Molla, 2009; Jnr et al., 2020).
	GU2	We applied energy control features for IT equipment in our firm.	
	GU3	Switch off equipment when not in use to reduce energy usage.	
	GU4	Encourage our staffs to adopt double side printing.	
	GU5	Utilizes IT facilities to monitor capabilities and put in sleep mode when idle.	
	GU6	Uses natural cooling within our organization to decrease electricity cost.	
End of Life	EL1	Recycle expendable apparatus such as paper, ink cartridges and batteries.	(Murugesan, 2008; Molla, 2009; Schmidt et al., 2009; Jnr et al., 2020).
	EL2	Ethically dispose outdated IT hardware in an eco-friendly approach.	
	EL3	Implement policy on dealing with e-waste.	
	EL4	Reuse IT facilities in our firm.	
	EL5	Refurbish and repair obsolete IT hardware.	
Green Distribution	GD1	Install applications to make logistics eco-friendlier.	(Elliot and Binney, 2008; Velte et al., 2008; Schmidt et al., 2009; Jnr et al., 2020).
	GD2	Replaces all systems to energy efficient systems in our firm.	
	GD3	Use software to analyze electricity usage.	
	GD4	Hire the services of expert to maintain our IT facilities.	
	GD5	Install more electricity proficient lightings in our firm.	
	GD6	Advance to effectual transformers and UPS in our firm.	
	GD7	Monitor electricity usage across the firm.	
	GD8	Eliminates and replace unused IT based systems.	

5. Results

In reporting the survey results, four steps are employed. First, the demographic data are reported, then data exploration, descriptive statistics, and lastly inferential statistics.

Table 4 Characteristic of the survey respondents

Demographic Profile	**Options**	**Frequency**
Gender	Male	76
	Female	57
Age	< 25	1
	25-34	55
	35-44	59
	45-55	17
	>55	1
Educational Status	High School	4
	Diploma	30
	BSc	43
	MSc	37
	Doctorate	19
Industry	IT based firms	49
	Academic/Research Institutions	66

	Health and Public Relation	2
	Engineering and Construction	2
	Government based Institutions	11
	Personal, Professional	1
	Other_Services	2
Job Description	IT Practitioner	37
	IT Executives	26
	Support Staffs	20
	Non IT Executives	6
	Academic Practitioner	13
	IT Administrators and IT Specialists	7
	Other_Positions	24
Years of Experience	0-5	42
	6-10	31
	11-15	35
	16-20	15
	>20	10
Business Size	Below 50 employees	14
	51-250 employees	23
	251- 1000 employees	25
	Above 1000 employees	71
Date Established	Before 1967	10
	Between 1967-1980	26
	Between 1991-2000	52
	Between 2001- 2010	37
	From 2011- Till date	8
Business Income	RM 90,000 < below	19
	RM 90,000-RM 900, 000	14
	RM 900,000-RM 2, 700,000	32
	RM 2,700,000-RM 4,500,000	15
	RM 4, 500,000-RM 9, 000,000	12
	RM 9,000,000 and above	41

Table 4 shows the demographic characteristic of the survey respondents. The internal and external characteristics (independent variables) (see Table 2) were measured based on a 5 point Likert scale ranging from not significant as “1” and very significant as “5” to examine research question 1 whereas the sustainable life cycle process (see Table 3) are similarly measured with a 5 point Likert scale ranging from not deployed as “1” and fully deployed as “5” to explore research question 2. Furthermore, results from Table 4 suggest that most of the CEs involved in the study are from academic/research institutions and IT based firms who mainly implement Green usage for reducing energy usage with a mean of 3.51 and end of life with a mean of 3.49 for reuse, recycle and refurbish with a mean of 3.49. In terms of years, results of Table 4 indicate that Green IT/IS innovation has been adopted from between 1991-2000 and between 2001- 2010.

5.1. Explorative and Descriptive Analysis

This phase helps to present the screening and filtering of the dataset to assess for potential sources of bias. Hence, out of the received 133 survey responses, 82% where complete answer and 18% had missing values. Since the response is low, the missing values had to be treated by replacing the missing values with mean value (using SPSS). Then, the author proceeded to search for multivariate outliers using boxplots and also calculating the Mahalanobis d-squared values which should be lesser than 0.01 (Field, 2009) for all response and found that most of the responses were all within a satisfactory range (<0.01). Resulting to a total usable sample of 133 datasets, after which the normality, reliability and construct validity test of dataset was carried out. Additionally, the mean and standard deviation of the constructs are shown in Table 5.

Table 5 shows the explorative and descriptive analysis, outlining the normality test of dataset using Kurtosis and Skewness calculated using SPSS, where the Kurtosis and Skewness values between ±2 are considered effective as recommended by George and Mallery (2005). Therefore, all values of our constructs are between the suggested ranges as presented in Table 5. All constructs mean values are higher than 2.5 and the Standard Deviation (SD) values are lower than 1 showing that the reply from the participants are close and not extensively distributed. Besides, the reliability of the questionnaire instrument is assessed using Cronbach's α (CA) as recommended by Shelby (2011). Where, the Cronbach's (α) coefficient should be higher than or equal to 0.7 (Hair et al., 2006). Thus, all constructs Cronbach's coefficients are greater than 0.7 as shown in Table 5. This indicate that the questionnaire instruments employed has good reliability and suitable for this study.

Table 5 Test of normality, explorative and descriptive analysis

Concept	Constructs	Normality Test		Descriptive Analysis		Explorative Analysis	
		Skewness	Kurtosis	Mean	SD	Cronbach's Alpha	Pearson Correlation
Internal and External Characteristics	Human Resources	-0.071	-1.416	3.93	0.736	0.951	0.323**
	IT Governance	-0.131	-1.519	3.98	0.773	0.949	0.409**
	Technological Integration	0.071	-1.087	3.79	0.771	0.947	0.511**
	Competitive Strategy	0.163	-1.138	3.77	0.774	0.946	0.536**
	Information Intensity	0.164	-1.398	3.80	0.819	0.945	0.547**
	Regulatory Environment	0.226	-0.983	3.60	0.706	0.945	0.587**
Sustainable Life Cycle Process	Green Creation	0.013	-0.078	3.46	0.812	0.944	0.903**
	Green Distribution	-0.282	-0.041	3.35	0.910	0.947	0.935**
	Green Sourcing	-0.277	-0.080	3.25	0.967	0.949	0.932**
	Green Usage	-0.087	-0.048	3.51	0.836	0.942	0.943**
	End of Life	-0.079	0.163	3.49	0.846	0.945	0.901**
Dependent Variable	Green IT/IS Innovation	0.058	-0.507	3.41	0.807	0.943	1.000**
Sampling Size Adequacy Test	Valid N (listwise)	133	Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.902, Bartlett's Test of Sphericity = 925.954, df= 21, (2-tailed) = 0.000 **. Correlation is significant at p= 0.01 level using 2-tailed and N =133.				

Additionally, the reliability of the constructs can be examined using the explorative factor analysis employed by checking for the Kaiser-Meyer-Olkin (KMO) measure of sampling acceptability test (Field, 2009). Where, KMO values around 0.5 are hardly acceptable, (0.5–0.7) values is average, (0.7–0.8) is acceptable, (0.8–0.9) is great, and lastly (above 0.9) is considered excellent (Hutcheson and Sofroniou, 1999). Thus, results from Table 5 depict that the KMO is = 0.902 which is higher than the 0.5 limit. This reveal that the questionnaire instruments scale employed is valid at a significance of 0.000. Furthermore, the Bartlett's test of sphericity $\chi 2$ (21) = 925.954, $p < 0.000$, indicated that relationships between items were sufficiently large for inferential analysis. Next, the validity of the instrument was evaluated in terms of face, content and constructs validity. DeVellis (2003) stated that face validity aids to maximize the suitability when developing scales. Hence, domain experts were utilized to review the questionnaire items to ascertain the item relevance (as stated in section 4.2). Moreover, content validity was confirmed since all the constructs in the developed model (see Figure 4) were derived from literature on Green IT/IS (see Section 3.1 and 3.2).

According to Cohen et al. (2013) the strength of relationship, correlation coefficient strengths ranges from 0.1 to 0.29 as Weak, 0.30 to 0.49 as Moderate and 0.50 to 1.0 as Strong. Table 5 also shows the correlation analysis between Green IT/IS innovation (dependent variable) and constructs, where the Pearson correlation coefficient (r) (must be between -1 to +1), p is the probability significance (that must be less than 0.01 to be valid) and N is the sample size (133). Results from Table 5 suggest that the Pearson's correlation (r) value was above 0.3 to 0.9 representing a medium and strong positive correlation, signifying that the constructs are statistically significant at p = 0.000. Thus, confirming the quality of the samples (Straub et al., 2004). The results of the correlation fulfil the criteria for validity (Straub et al., 2004).

5.2. Inferential Analysis (Hypothesis Testing)

This phase helps to validate the research model by testing the hypotheses.

5.2.1. Regression Test for H1-H6 and H7-H11

After presenting the test for normality, reliability and correlation, this study proceeds to carryout linear regression analysis to confirm or reject the relationship between the independent and dependent variable. Where, regression analysis is particularly flexible and versatile as such can be utilized to reveal measurable reliance among variables (Field, 2009). Linear regression is normally employed when both dependent and independent variables are scale or ordinal. Besides, regression analysis was selected because of its superior applicability and comprehensibility and for examining interaction effects. Thus, Table 6-7 shows the regression analyses test carried out to evaluate the hypothesized relationships as seen in Figure 4 (H1 to H6 and H7- H11) using SPSS.

Table 6 Regression analyses between independent variables and dependent variable (H1-H6)

Dependent Variable: Green IT/IS Innovation	**Collinearity Statistics**	**Regression Analysis**						
Internal and External Characteristics	**Tolerance**	**F-Tests**	**R^2**	**Beta**	**Standard Error**	**t-test**	**p-value (Sig.)**	**Decision**
Human Resources	0.276	15.271	0.104	0.323	0.091	3.908	0.000	Valid
IT Governance	0.188	26.315	0.167	0.409	0.083	5.130	0.000	Valid
Technological Integration	0.293	46.213	0.261	0.511	0.079	6.798	0.000	Valid
Competitive Strategy	0.133	52.742	0.287	0.536	0.077	7.262	0.000	Valid
Information Intensity	0.159	56.012	0.300	0.547	0.072	7.484	0.000	Valid
Regulatory Environment	0.225	69.018	0.345	0.587	0.081	8.308	0.000	Valid
Decision: Hypothesis is Valid if t-value => 1.96 and p-value=<0.05								

Figure 5 and Table 6 shows the result of inferential test using regression analysis between the independent variables and Green IT/IS innovation where the results outline the goodness of fit relationship test, namely; F-test for the variables given as 15.271, 26.315, 46.213, 69.018, 52.742 and 56.012 with p-value 0.000 outlining the test is highly significant for all independent variables. Since p-value of F-test is less than significance level p=0.05, therefore confirms that there is a significant relationship between the constructs and Green IT/IS innovation. The strength of relationships is measured by examining R^2 of all the constructs where R^2= 0.104 for human resources shows that the construct has been interpreted at 10.4% of the variance, next is IT governance with R^2 =0.167 interpreting at

16.7% of the variance. Where, technological integration has an R^2 =0.261 interpreting at 26.1% of the variance, next is competitive strategy with R^2=0.287 interpreting at 28.7% of the variance followed by is information intensity with R^2 =0.300 interpreting at 30% of the variance and lastly is regulatory environment which has the highest R^2 =0.345 interpreting at 34.5% of the variance in Green IT/IS innovation confirming that there exist a strong relationship associated with the constructs and dependent variable.

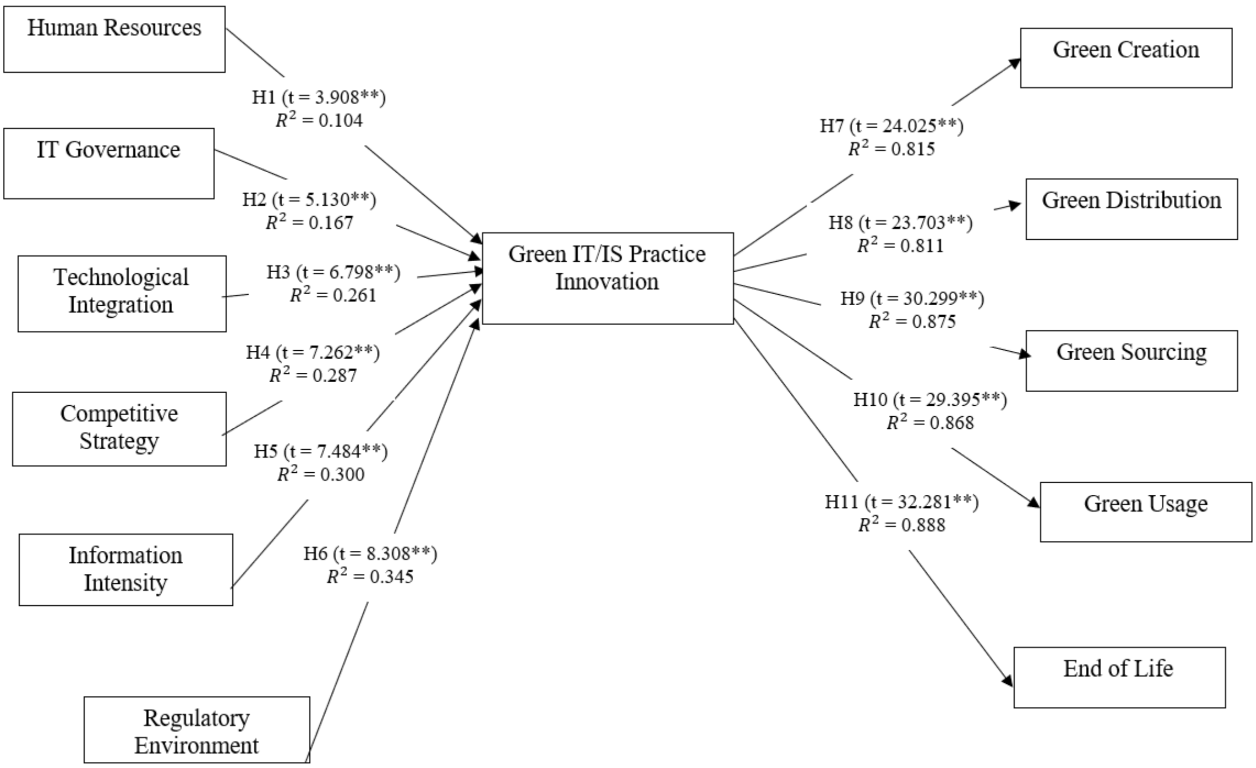

Figure 5 Results of t and R^2 values from regression analysis for (H1-H11)

Additionally, all the constructs has a direct impact on the Green IT/IS innovation (as shown in positive beta result (β = 0.323, 0.409, 0.511, 0.587, 0.536, 0.547)), which express the relative importance of the variables where the tolerance value is greater than 0.01 for all constructs (showing that collinearity is not any issue) (Brace et al., 2003). In terms of improvement, increase 1 unit in all constructs, Green IT/IS innovation will increase by 0.32 (32%) unit for human resources, 0.409 (40.9%) unit for IT governance, 0.511(51.1%) unit for technological integration, 0.536 (53.6%) units for competitive strategy, 0.547 (54.7%) units for information intensity and lastly 0.587 (58.7%) units for regulatory environment. Moreover, considering the t-test value as seen in Table 6 and Figure 5 for independent variables (3.908, 5.130, 6.798, 8.308, 7.262, 7.484) are higher than 1.96 benchmark as recommended by Hair et al. (2006), showing that the independent variables in this study are significant and valid, with regulatory environment being the most significant construct at t = 8.308, p = 0.000 and human resources being the least significant construct at t = 3.908, p = 0.000.

Results from Table 6 and Figure 5 show that H1 human resources positively influences Green IT/IS innovation with path coefficient (β) is 0.323 (t=3.908, R^2 =0.104), therefore supporting H1 since t-value is greater than 1.96 benchmark and path coefficient is higher than “0” (Anthony Jr, 2019). Similarly, H2 states that IT governance positively influences Green IT/IS innovation. The results further suggest that H2 path coefficient is 0.409 (t=5.130, R^2 =0.167), therefore supporting H2. Next, H3 states that technological integration has direct impact on Green IT/IS innovation. Accordingly, results from Figure 5 disclose that the hypothesis is significant where path coefficient is 0.511 (t=6.798, R^2=0.261). Similarly, the results reveal that available competitive strategy have a positive influence on Green IT/IS innovation (H4) with path coefficient of 0.536 (t=7.262, R^2=0.287). Likewise, the results confirm H5 which suggest that information intensity positively influences Green IT/IS innovation with path coefficient of 0.547 (t=7.484, R^2 =0.300), thus supporting H5. In addition, H6 states that regulatory environment positively influences Green IT/IS innovation. The results confirm that H6 path coefficient is 0.587 (t=8.308, R^2 =0.345), therefore supporting H6. These results confirm the applicability of DoI theory for assessing Green IT/IS innovation in CE as such hypotheses (H1-H6) are valid.

Table 7 Regression analyses for Green IT/IS process and dependent variable (H7-H11)

Dependent Variable: Green IT/IS Innovation	**Collinearity Statistics**	**Regression Analysis**					
Sustainable Life Cycle Process	**Tolerance**	**R^2**	**Beta**	**Standard Error**	**t-test**	**P-value (Sig.)**	**Decision**
Green Creation	0.253	0.815	0.903	0.037	24.025	0.000	Valid
Green Distribution	0.174	0.875	0.935	0.027	30.299	0.000	Valid
Green Sourcing	0.206	0.868	0.932	0.026	29.395	0.000	Valid
Green Usage	0.150	0.888	0.943	0.028	32.281	0.000	Valid
End of Life	0.221	0.811	0.901	0.036	23.703	0.000	Valid
Decision: Hypothesis is Valid if t-value => 1.96 and p-value=<0.05							

The regression analysis result between Green IT/IS innovation and sustainable life cycle process as presented in Table 7 and Figure 5 reveal that the p-value of all G sustainable life cycle process equals to 0.000. Since, p-value is less than significance level p=0.05, conclude that there is significant correlation between Green IT/IS innovation and sustainable life cycle process. Additionally, the sustainable life cycle process was also examined for multicollinearity and results suggest that the tolerance values of all sustainable life cycle process are higher than 0.10 (Brace et al., 2003) illustrating that multicollinearity is not a problem. The strength of relationship is measured by examining R^2= 0.815, 0.875, 0.868, 0.888, 0.811 is >0 <1 Hair et al. (2006) and beta value β = 0.903, 0.935, 0.932, 0.943, 0.901 showing a strong relationship. Additionally, Table 7 shows an encouraging t-test value which is greater than 1.96 as stated by Hair et al. (2006).

Results from Table 7 and Figure 5 show that H7 Green creation is positively influenced by Green IT/IS innovation with path coefficient (β) is 0.903 (t=24.025, R^2 =0.815), therefore supporting H7 since t-value is greater than 1.96 benchmark and path coefficient is higher than “0” (Anthony Jr, 2019). Similarly, the results confirm H8 which suggest that Green distribution is positively influenced by Green IT/IS innovation with path coefficient of 0.935 (t=30.299, R^2 =0.875), thus supporting H8. Similarly, H9 states that Green sourcing positively creation is significantly influenced by Green IT/IS innovation. The results indicate that H9 path coefficient is 0.409 (t=5.130, R^2 =0.167), therefore confirming H9. Next, H10 states that Green usage is directly impacted by Green IT/IS innovation.

Accordingly, results from Table 7 and Figure 5 disclose that the hypothesis is significant where path coefficient is 0.943 (t=32.281, R^2=0.888). Likewise, the results reveal that end of life is positively influenced by Green IT/IS innovation (H11) with path coefficient of 0.901 (t=23.703, R^2=0.811), thus confirming H11. Based on this result, this study concludes that Green IT/IS innovation is based on the current sustainable life cycle process practice implemented in CE as such hypotheses (H7-H11) are valid.

6. Discussion

This study examines Green IT/IS innovation in CE, by developing a research model based on DoI theory. Data was collected using survey to validate the developed model using inferential statistics by employing regression analysis. Results from the demographic characteristics of the respondents (see Table 4) of CEs based in Malaysia which is a developing country depicting that 42% of respondents possess a maximum experience of 5 years' and another 35% have experience of 11-15 years in adopting Green IT/IS innovation. This implies that Malaysia being an emerging economy is still evolving as such only a few CEs are diffusing Green IT/IS innovation in their business operation. In comparison to Green IT/IS innovation in developed countries such as Australia (Molla et al., 2014), USA (Loeser et al., 2017), Germany (Schmidt et al., 2011), and Finland (Lintukangas et al., 2014) results from these studies suggested that the respondents years of experience in diffusing eco-friendly practices are higher than that of Malaysia that because CEs in Malaysia started deploying Green IT/IS innovation in 2009 (Anthony Jnr et al., 2019) which was late in comparison to developed economies.

Results from the regression test indicate supports for hypotheses (H1-H7) suggesting that human resources commitment is mandatory for businesses initiating Green IT/IS innovation. This result is consistent with findings of prior studies (Deng and Ji, 2015; Loeser et al., 2017), implying that staffs' collaboration is based on their shared concern and commitment in fulfilling the objectives of the enterprise. This can be seen as part of the environmental ethics or stewards in the enterprise. In addition, results suggest that IT governance policies initiated by the management influences how staffs adopt Green IT/IS innovation in CE. As Zheng (2014) stressed that organization must provide rules and awareness program to enlighten staffs on how practices such as telematics can progress Green IT/IS innovation. The results lead to the conclusion that commitment of management is essential in promoting Green IT/IS innovation.

The results of this research support that there is a significant relationship between integrated technologies and Green IT/IS innovation. This is analogous to findings presented by previous research (Karanasios et al., 2010; Akman and Mishra, 2014) where, the authors mentioned that technologies which refer to infrastructures enable sustainable related operations in CE. The results suggest that strategies deployed by businesses to achieve their objectives significant determines Green IT/IS innovation. This is in line with findings of prior studies conducted in other countries (Stan et al., 2010; Decio et al., 2015). So, it is recommended that competitive strategies deployed by firms should support in reducing businesses daily operating costs. Results from this study indicate that the intensity of information provided influences Green IT/IS innovation in CE, this is similar to findings presented by Hasan et al. (2012); Butler (2011b), where the authors mentioned that information dissemination regarding Green IT/IS can assist to decrease energy consumption and cost incurred. The outcomes of this research also support the hypothesis that there is significant relationship between regulatory environment and Green IT/IS innovation. This finding is consistent with results of prior research (Vykoukal et al., 2011; Ainin et al., 2016). The results indicate that businesses are motivated by social, internal and external pressure that determines how they conducts business in relation to Green IT/IS innovation. This is based on environmental rules set mostly by government and external environmental bodies such as Greenpeace.

Further results from regression test reveal that sustainable life cycle process hypotheses (H7-H11) for Green creation, Green distribution, Green sourcing, Green usage, and end of life are based on the current Green IT/IS innovation being diffused in CE. Findings from this study support hypotheses (H7-H11), where the results reveal that the current Green IT/IS innovation significantly influence Green creation as previously stated by Ninlawan et al. (2010) where the researcher mentioned that Green creation involves the utilization of information systems for enterprise operations, ecological management and carbon foot print assessment in CEs design operations. The results show that Green IT/IS innovation influences Green sourcing which reflects on environmentally preferable IT infrastructure procuring in CE. This result is consistent with the previous results presented by Molla et al. (2009); Pichetpongsa and Campeanu (2011), where the authors found out that Green sourcing procedure in CE includes social concerns such as the presence of harmful elements in IT hardware when making Green procurement decisions.

An intriguing outcome of the study is that Green usage is based on Green IT/IS innovation implemented in the enterprise by enhancing power efficacy in cooling and powering enterprise IT infrastructures and also decreases IT induced CO_2 emissions. Accordingly, it can be interpreted from the result that Green usage aims to bring about energy consumption decrease similar to findings presented by Anthony et al. (2020) in their study. Furthermore, results from this study indicate that end of life management towards Green disposal is also influenced by Green IT/IS innovation similar to results presented by Pichetpongsa and Campeanu (2011) in their case study research conducted in Dell and Toshiba corporations, where their study suggests that end of life entails the practices of refurbishing, reusing, recycling and disposing of IT equipment in an ethical eco-friendly manner. The result also implies that the current Green IT/IS innovation significantly influence Green distribution in CE. This result is analogous to the statement posits by Raza et al. (2012) where the researchers mentioned that Green distribution emboldens operative procedures that increases the reutilization and reuse of raw materials to encourage minimal unwanted materialization thereby lowering resource consumption.

7. Implication of Study

7.1. Implications for Research

Green IS materialized after the perception of Green IT proved its success in theory and practice by decreasing the negative environmental effects of IT hardware. After Green IT initiatives made the design and deployment of IT ominously more sustainable. Green IT addressed roughly 2 per cent of CO_2 emission caused by IT usage. Green IS is more concerned about resolving the cause of the outstanding 98 per cent. Thus, combining both Green IT and Green IS as Green IT/IS in our study can help address 100 % emission caused by the first order effect of IT deployment in CE by utilizing information systems and technology that foster sustainability related objectives throughout CE. While, Green IT/IS innovation offer huge prospective on the corporate level, few studies have been carried out concerning the integration of Green IT and Green IS as Green IT/IS in CE.

Green IT/IS innovation has research implications for the initiatives to be taken towards promoting sustainability attainment in CE, where sustainability is usually defined as finding equilibrium between the economy, society and environment. Findings from literatures suggested that the utilization of energy efficient infrastructures (Green IT) does not essentially lead to complete lessening of energy consumption, since these efficient systems and appliances also stimulate the utilization of natural resources. This is known as paradox or the rebound effect. Hence, findings from this study suggest that businesses should integrate Green IS into existing Green IT practices as Green IT/IS. Moreover, this study suggest that Green IT/IS promises a much better, enterprise-wide potential to monitor, measure, report and lessen CE's ecological footprint. Thus, findings from this study help in addressing paradox or the rebound effect of IT usage in CE and provides insights on Green IT/IS innovation in businesses.

Presently organizations are under pressure from regulators, customers, society and competitors to implement eco-friendly enterprise practices. Hence, balancing ecological responsibility is a strategic issue; as a result, IT managers can draw upon the model in this paper in evaluating the conditions for successful Green IT/IS innovation for corporate ecological responsibility. Theoretically, the developed model help policy maker understands the strength and weakness of their current environmental practices. Furthermore, the model shows how IT practitioner and IT managers can align organizational technological and environmental factors to improve ecological performance in the present and future. Besides, results from this study aims to support CEs understand the potential values of Green IT/IS innovation towards creating competitive advantage.

Furthermore, this research significantly contributes to the body of knowledge as it presents the conceptual base that outlines the correlation between the action of IT practitioners and management towards Green IT/IS innovation and creation of sustainability values as outcomes for the enterprise. Hence, to achieve the potentials of Green IT/IS, staffs and managers must make significant changes to their sustainability orientation since their beliefs, behaviour, values and norms are important attributes that impacts Green IT/IS innovation. IT Managers can refer to the developed model to diffuse Green IT/IS innovation in their businesses to support sound enterprise sustainability governance throughout all departments by fostering ecological friendly products and services. In addition, prior Green IT/IS studies mainly focused on the environmental (planet) and economic (profit) dimension of sustainability but has paid less attention to the social benefits. Accordingly, this research offers a social dimension of sustainability orientation, which supports practitioners' decision-making procedures towards Green IT/IS innovation for economic and environmental benefits by examining internal and external characteristics that influences Green IT/IS innovation.

7.2. Implications for Practice

This current study provides practical implications for businesses wishing to implement or enhance their current sustainability responsiveness. Moreover, this study derived a measurement instrument (see Table 2 and 3) that provides best practice recommendation towards Green IT/IS. Therefore, Green IT/IS innovation can help diminish costs incurred which addresses enterprise creation, distribution, sourcing, usage, and end of life of IT equipment towards improving enterprise reputations and strengthening environmental responsiveness. Furthermore, findings from this study provides implication for practitioners to choose from sustainable life cycle process towards improving their current environmental performance based on sustainability goal they wish to attain. Additionally, findings from this study provide IT managers and environmental practitioners with suggestions on how to proficiently deploy Green IT/IS into the overall enterprise strategy. Correspondingly, the sustainable life cycle process derived in this study can be practically implemented by managers to enhance the firms' environmental policies and operations for corporate ecological responsibility.

Furthermore, to better attain environmental responsibility, businesses are required to design effective initiatives to accelerate Green IT/IS innovation. Importantly, this study offers academicians with alternative technical paradigm in understanding Green IT/IS innovation by incorporating those industry reports to help understand not only the factors that influences Green IT/IS innovation as seen in Figure 4 but also what extents these factors influences corporate ecological performance. This indicates that organizations should pay careful attention to these factors. Practically, findings from this study suggest that Green IT/IS can be adopted in organizations by utilizing IS to mitigate and control contaminating emissions and wastes during and after enterprise operations. Thus, Green IT/IS innovation may also involve use of IS based applications to lessen pollution produced by organizational activities. Hence, in mitigating pollution, managers may promote the uses IS infrastructure towards innovative carbon and energy assessment, control application or telematics applications to decrease industrial's carbon footprint.

In addition, CEs in Malaysia were chosen as case base for this study because nowadays Malaysia businesses carryout their organizational services by deploying and utilizing resources that are facilitated by IT infrastructures which consumes electricity thereby emitting CO_2 to the atmosphere that adds to climatic changes, global warming and environmental degradation. Hence, based on diffusion of innovation theory this study explores on factors that influence CEs in adopting Green IT/IS innovation in bringing about cost saving decrease, energy efficiency, eco-friendly waste management, natural resource conservation and CO_2 emission reduction towards corporate ecological responsibility. Similarly, this study provides and validates the sustainable life cycle process to be implemented in CEs that utilized IT infrastructures in facilitating their enterprise business operations.

Results from this study are applicable to firms in Malaysia as well as CEs in other developing and developed economies in improving enterprise environmental governance policies in decreasing energy utilization of IT infrastructures which is related to operational cost reductions. Thus, the derived sustainable life cycle process are important towards enabling enterprise gain capabilities to resolve sustainability issues as well as delivering viable value to investors and gain sustained economic advantage. Apparently, there is necessity for Green IT/IS innovation that inculcates aspects of environmental sustainability to support enterprise objectives while leveraging organizations competitiveness. To summarize this argument, Green IT/IS have the prospective to enhance environmental, social and economic sustainability of CE. However, it is to be noted that the potential of Green IT/IS can only be achieved if the current enterprise strategies are aligned with environmental, social and economic initiatives. The take-home message from the study is that although IT is seen as contributed to environmental issues such as global warming, climatic changes and environmental degradation, IT facilitated by IS can also be a solution for conserving the natural environment towards attaining sustainability.

8. Conclusion, Limitations and Future work

The term Green IT became prevalent after the publication of a Gartner report in 2007 Gartner (2008) and was later linked by Green computing and Green IS. Murugesan (2008) defined Green IT as the study and practice of developing, producing, utilizing and disposing of computers, servers, and related subsystems effectively and efficiently with negligible or no effect on the natural environment. The dichotomy between decreasing the footprint of IT itself and using IT to facilitate sustainability is termed as Green IT/IS. Hence, Green IT/IS innovation refers to CE perspective towards investing, deploying, usage and managing of IT/IS to lessen the negative ecological impacts of IT infrastructure through the deployment of IS facilitated services and products, to promote enterprise operations. Although, the transformation of any enterprise process with the support of Green IS entails a holistic long-term governance plan. Therefore, this study integrates Green IT and Green IS as Green IT/IS to support CE diffuse both Green IT and Green IS practices in achieving societal, environmental and economic needs for sustainability attainment.

Accordingly, in the context of sustainability, this study develops a research model grounded by diffusion of innovation theory after which survey method was employed to validate the model hypotheses using SPSS. However, it is imperative to note that the developed model and hypotheses in this study and its findings are not without limitations. First, the limitation of this study relates to the sample size which was limited based on the low response from invited participants. Although, the author does not claim that the sample in this research is a representative of all CEs in Malaysia, the study still provides useful insights on current Green IT/IS innovation being adopted in CEs based in Malaysia. Additionally, since this research was intended to examine Green IT/IS innovation in most cases the IT departments of CEs, the author only invited IT practitioners and IT managers in IT departments of CEs that adopts Green IT/IS innovation by getting their detail from their enterprise websites.

Secondly, another limitation is that the study only examined CEs based in Malaysia. The results might differ for other CEs based in other countries. Hence, findings from this study cannot be generalized to other countries. Thirdly, an additional limitation is the use of respondents who are either IT practitioners or IT managers as participants for our study leading to only 133 samples utilized in this study. Thus, a multiple-respondents method that included both staffs and experts from other domains would be of interest. Lastly, only SPSS was utilized to evaluate the research model, no other statistical tool was incorporated in this study. Accordingly, further research would be necessary to carry out a longitudinal study to collect data from multiple respondents based in more than one country to increase sample size. Although, SPSS was utilized to analyse the data from the survey, Partial Least Square-Structural Equation Modelling (PLS-SEM) can be employed to compare and confirm the results obtain from SPSS in this study.

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Highlights

- This research examines Green Information Technology and Information Systems (IT/IS) innovation.
- Developed a model based on Diffusion of Innovation (DoI) Theory.
- The model constructs were identified through an extensive literature review after which survey method was employed.
- Results reveal that internal and external characteristics influences enterprise sustainability innovativeness.
- Furthermore, results suggest that Green IT/IS innovation is based on the current sustainable life cycle process.