Critical factors in information technology capability for enhancing firm's environmental performance: case of Indonesian ICT sector

Darius Antoni*, Ferry Jie and Ahmad Abareshi

Faculty of Computer Science,
Universitas Bina Darma,
Jalan Jenderal Ahmad Yani,
No. 3 Plaju Palembang, Indonesia

and

School of Business and Law,
Edith Cowan University,
270 Joondalup Drive,
Joondalup, 6027, Western Australia

and

School of Business IT and Logistics,
RMIT University,
445 Swanston St.,
VIC 3000, Melbourne, Australia
Email: Darius.antoni@binadarma.ac.id
Email: f.jie@ecu.edu.au
Email: ahmad.abareshi@rmit.edu.au
*Corresponding author

Abstract: Information technology (IT) capability can be adopted by organisations to improve their environmental performance in order to meet environmental regulations, improve their profitability and enhance their competitive position in the marketplace. The main purpose of this paper is to develop a research framework which can serve as a basis to understand how IT capability leads to improvement of environmental performance and what critical IT capabilities would improve environmental performance in an organisation. The hypothesised framework is developed based on a review of the literature on Resource Based View theory and green IT. The sampling unit of this study is from managerial levels in selected 1265 Indonesian ICT organisations based on the list provided by the Ministry of Trade, Republic of Indonesia. The findings show that environmental performance is influenced by IT infrastructure quality, IT human resources competence, and environmental IT competence.

Keywords: IT capability; environmental performance; IT infrastructure; IT human resources; green IT; ICT industry; Indonesia.

Reference to this paper should be made as follows: Antoni, D., Jie, F. and Abareshi, A. (2020) 'Critical factors in information technology capability for enhancing firm's environmental performance: case of Indonesian ICT sector', *Int. J. Agile Systems and Management*, Vol. 13, No. 2, pp.159–181.

Biographical notes: Darius Antoni is an Information Technology (IT) Researcher at the Universitas Bina Darma, Palembang, Indonesia. He seeks to uncover mechanisms of IT capability to leads to improvement of environmental performance and what critical IT capabilities would improve environmental performance in an organisation. In addition, currently his research mainly focuses on the role of IT in e-government. His approach is based on IT infrastructure capability and Resource Based View Theory. He received his Bachelor and Master degrees from the Universitas Bina Darma and PhD in Information Systems from the Royal Melbourne Institute and Technology (RMIT) University, Melbourne, Australia. Currently, he is Head of Master Study Program in Informatics, Universitas Bina Darma Palembang, Indonesia.

Ferry Jie is an Associate Professor in Supply Chain and Logistics Management in the Commerce discipline at the School of Business and Law, and the Deputy Director, Centre of Innovative Practice. He has maintained a high quality of research throughout his academic career including international scholarly leadership in the areas of supply chain management and logistics, including being invited to be keynote speaker and to give public lectures at symposiums and international conferences in Indonesia, Malaysia, Vietnam, China, UK and Australia. From 2010 to 2019, he has published 62 refereed journal articles (including 12 (eight) articles in A Ranked Journal – ABDC Journal Lists) and 41 refereed conference papers. Furthermore, he has received research grants/awards to the amount of $1,604,604.07 between 2010 and 2019.

Ahmad Abareshi is a Senior Lecturer at School of Business IT and Logistics at RMIT University. His research focuses on the application of IT in logistics, green IT, and supply chain. His work has been published in journals such as *Journal of Computer Information Systems*, *Transportation Research Part E*, *Transportation Research Part D*, *Information Technology & People* and various others.

1 Introduction

Concerns about the environmental performance of industry have become an increasingly high profile issue in many industries (Jenkins and Yakovleva, 2006). The environment is one of key components of the triple bottom line framework that can help an organisation for conceptualising, managing and reporting their business to build sustainable competitive advantage. Porter and Van der Linde (1995) argue that pollution is a form of waste, that if eliminated will improve productivity and that the environmental performance can improve efficiency of processes and reduce costs of compliance. It is also argued that information technology has played a pivotal role in driving changes in logistics industry. "…innovation is gaining importance in the logistics industry. The advent of new technologies and globalisation has inspired firms to look for new solutions for the challenge of business in today's competitive landscape" (Nagarajan and White, 2008, p.305).

There are many strategies and approaches to improve the environmental performance. For example, Olsthoorn et al. (2001) state that the environmental performance of an organisation can be enhanced by the initiatives and actions that an organisation takes

for reducing the consumption of natural resources and the impact of its operations on the natural environment. Singh et al. (2009) state that the improvement of environmental performance of an organisation can be reflected by the natural resources consumed, the waste produced, the proportion of the waste being treated, and the impact of its operations on the environment. While there has been much research concentrating on how information technologies can enable firms to overcome these technical barriers in improving environmental performance (Fürst and Oberhofer, 2012) our understanding on the role of IT as a solution for environmental sustainability is in its initial stages (Wang et al., 2015). Using ecological modernisation perspective Jänicke (2008) argues that marketable technological solutions for environmental problems offer a broad spectrum of 'win-win-solutions'. Several research have called attention on to explain whether and how IT can enable firms to pursue environmental sustainability (Melville, 2010; Watson et al., 2010). Given a need to develop a better theoretical framework to understand how the IT capability is used to improve environmental performance, the main purpose of this paper is to develop a research framework which can serve as a basis to understand how IT capability leads to improvement of environmental performance and what critical IT capabilities would improve environmental performance in an organisation. This is because the IT has ability to play a crucial role in both greening its operations and services and supporting business's overall environmental sustainability objectives (Molla et al., 2008). This paper is based on the resources-based view which considers an organisation to be heterogeneous packages of the resources that have capabilities and characteristics to predict organisational success (Barney, 1991; Bharadwaj, 2000). From this perspective, the resources can be seen as a basis of capabilities to gain and maintain the competitive advantage in the competitive business environment. Extending this view to the use of IT capability in improving environmental performance, IT capabilities represent the ability of an organisation in effectively and efficiently use of IT resources for improving environmental performance.

The rest of the paper is organised as follows. In the next section, the theoretical foundation is discussed leading to the research model and the hypotheses development. We then outline the research methodology which is followed by a comprehensive analysis of the data, leading to the validation and testing of the proposed framework. Finally, the research findings and their implications are discussed in next section followed by conclusion as the last section. This will be followed by the discussion on the research methodology. Next section discusses findings and the last section offers the conclusion and limitations.

2 Theoretical foundation

Improvement of environmental performance in organisations has been becoming popular in business activities. An effective improvement in environmental performance enables organisations to meet the government environmental regulations, improve organisations reputation, comply with environmental standards, improve organisational profitability, provide organisations with business opportunities and improve the competitive position of organisation in the market place (Antoni and Jie, 2012; Zhu et al., 2005). As a result, organisations have been implementing specific strategies and policies to improve their environmental performance.

IT capability is concerned with the IT resources that can be used for sharing capabilities and services in order to support business operations and develop environmental competence of IT (Cooper and Molla, 2012). The concept of IT capability can be determined from many perspectives. Duncan (1995) posits a flexibility approach for employing IT capability and it is one associated with aligning IT and business objectives, business design and IT plans, and IT human resources skills. Bharadwaj (2000) shows that IT capability is the organisational ability that is created by the interaction of IT infrastructure, IT human resources, and IT intangible assets for improving organisational performance. Liu (2002) supports the notion that IT capability is the key to improving the efficiency and effectiveness of business operations. Harmon and Auseklis (2009) utilise the 'green computing' approach to integrate power management, virtualisation, recycling, electrical waste disposal and optimisation of IT capability, in order to decrease the impact of business operations on the environment. Similarly, Molla et al. (2009) involve 'green capabilities' to encompass the IT and communication resources of an organisation, along with the shared services and business applications. These studies show that the use of IT capability can develop an organisation's environmental competence.

Based on the above discussion, this paper aims to identify the critical factors for evaluating the IT capabilities when developing environmental competence in organisations from the perspective of quality of IT infrastructure and competence of IT human resources. A conceptual framework is hypothesised based on resource-based view theory as a theoretical lens to better understand how IT capabilities can be leveraged to improve environmental performance.

3 Environmental IT capabilities development

This study utilises the Resource Based Theory to develop environmental IT capability. The theory, developed by Wernerfelt (1984), asserts that organisations can gain and sustain competitive advantage by developing and deploying valuable resources and capabilities. Capabilities are complex bundles of skills and accumulated knowledge, exercised through organisational business processes, which enable organisations to control activities and to make good use of their assets (Day, 1994). RBV highlights the importance of resources and capabilities that are valuable, rare, inimitable and non-substitutable for delivering services or producing goods more economically (Barney, 1991). The characteristic of value refers to the capacity of organisational resources to make a difference in performance and create sustainable value for an organisation. Rarity refers to the scarcity of the resource, that is, the heterogeneously distributed nature of a resource which is possessed by few organisations. It can also refer to the resources of an organisation which have the potential to create a superior advantage for the organisation. The inimitable characteristic means that it would be difficult for other organisations to imitate or copy the resource. The non-substitutable attribute is a strategic resource that cannot easily be substituted. Therefore, RBV is a theory that covers key resources and capabilities which, when combined, enable an organisation to compete successfully with other organisations in the market (Barney, 1991).

Adopting RBV theory, scholars have identified several types of IT capabilities in organisations. For example, Kettinger et al. (1994) argue that the IT capability of an organisation for achieving competitive advantage is determined by its IT infrastructure. Bharadwaj (2000) states that IT capability is the organisational ability created by the interaction between IT infrastructure, IT human resources and IT intangible assets in an organisation for improving its organisational performance. Tippins and Sohi (2003) argue that IT capability is the ability of an organisation to use IT resources for improving its performance. Jiao et al. (2008) state that IT capability, determined by IT infrastructure, IT human resources and IT management, can be used for improving organisational performance. Therefore, RBV is used in this study to define IT related capabilities required for enhancing an environmental performance. In the following section the identified research constructs will be discussed.

3.1 IT infrastructure quality

IT infrastructure quality (ITQ) is about the foundation of IT resources that can be used for sharing capabilities and services in order to support business operations in organisations. Broadbent et al. (1999) and Broadbent and Weill (1997) define ITQ as a significant component of organisations for meeting market change, redesigning business processes and extending international or geographically dispersed operations. Therefore, ITQ is an essential competence or capability of organisations used to meet market needs and achieve business objectives.

In this study, it adopts the combined capability approach developed by Duncan (1995), Molla et al. (2008) to identify the abilities of IT infrastructure to be used for reducing the impact of business operations on the natural environment. Broadbent and Weill (1997) state that IT infrastructure has the capability to empower an organisation to adapt to the changing business environment and technological uncertainties. It might be determined by modularity, simple administration procedures, centralised database, external entry points, and storage virtualisation adoption.

The modularity of IT infrastructure refers to a technique used to improve the service to stakeholders by modifying, removing and adding any software, hardware, and data elements of IT infrastructure (Antoni, 2015; Duncan, 1995). For example, building information systems in an organisation through repeating IS functions such as data, or software, applications module call routine, as well as data can and will be converted into reusable objects. Thus, the use of data and applications component become independent and reusable. Furthermore, they enable to be parts of infrastructure and processes of development, maintenance, or engineering of direct-purpose systems are simplified and cost are reduced. The second capability of IT infrastructure is simple and familiar procedures. The simple procedure can be developed based on standardisation data and information used and shared services across the entire organisation in order to present uniform services for all business units by lower cost. Therefore, those activities can be leveraged by an organisation for creating environmental friendly business processes through creating simple procedure and rule (Molla et al., 2008).

Centralised database management system is critical IT infrastructure that can be utilised as capability to improve environmental performance of an organisation. This is because the centralised database is critical element of business process that can be used for improving environmental performance. For example, McKendrick (2010) states that the centralised database is used by organisation to more effectively grow their data

capabilities while reducing in staff time and operational costs. Chaudhuri et al. (2011) argues that the centralised database can increase flexibility and agility of existing computing infrastructure for reducing business operation costs. Thus, organisations can reduce the energy consumption in its business operations through increasing the utilisation of excess capacity possessed by centralised database.

IT infrastructure has the ability to connect internal and external business operations including business branches and units. It is showed that there is a need to provide an interface that can be utilised by organisation and its stakeholders to communicate each other's. For external stakeholders, organisation provide IS functions such as web access and applications acceded by stakeholder for business transactions. The stakeholder and organisations can share automatically and seamlessly across the level of functionality. Therefore, the interface of IT infrastructure can be used to support commonality between different applications and uses as well as facilitating information sharing across and outside the organisation, cross-functional integration of infrastructure and reducing business operation costs.

Virtualisation technology refers to IT infrastructure that has the ability to share services with different platform technologies including hardware platforms, base software platforms, communication technology and middleware (Thomas et al., 2016). It is also used to support commonality between different applications and uses as well as facilitating information sharing across and outside the organisation, cross-functional integration of infrastructure and reducing business operation costs. For example, Kovar (2008) argues that server virtualisations ensure critical business functions can be accomplished and user productivity remains high even during disruptions by achieving high availability at the device, network and data centre levels, and by providing displaced workers with fast, convenient, reliable and secure access to the desktops, applications and data they require to do their jobs.

Hypothesis 1: IT infrastructure quality has a positive impact on the firm's environmental performance

3.2 IT human resources competency

Besides ITQ, an organisation needs IT human resources that have competence to build and develop their information systems in order to improve organisational performance including environmental performance. Competence of IT human resources is determined by the technical skills and the managerial skills of the IT personnel available in an organisation (Benitez-Amado et al., 2010; Powell and Dent-Micallef, 1997). The technical skills are the abilities of IT personnel in programming, system analysis and design, network systems and communications, and competence in emerging technologies (Bharadwaj, 2000). Through these skill, IT human resources can contribute to the implementation of various IT-related applications for effectively and efficiently improving organisational operations (Powell and Dent-Micallef, 1997). Furthermore, the technical skills can assist the organisation to integrate IT and business processes more effectively. They can also create more efficient communications among business units through developing effective applications (Bharadwaj, 2000; Luftman, 2003; Thomas et al., 2016).

The technical capability of IT human resources is necessary but not enough. This is because the utilisation of IT infrastructure relies on both IT staff and management decision. With this capacity, the IT human resources can build a bridge between IT and business strategies by allocating appropriate resources for improving a business processes more effectively and efficiently (Pavlova, 2017; Speshock, 2010). Furthermore, with reliable IT human resources managers can coordinate various activities by successfully implementing specific IT applications (Bharadwaj, 2000). In addition, managerial skills can support the business process of an organisation by managing and redesigning environmentally sustainable business operations that reduce consumption of material and energy. The managerial competency of IT human resource help organisations to support their business process digitalisation and to develop IT environmental competencies. Managerial competency of IT human resources consist of knowledge of organisational plans and policies, business environment, alignment of IT and business strategies, management system standards, government regulations and standardisation of IT equipment.

In addition, Benitez-Amado et al. (2010) and Wehrmeyer (2017) state that IT human resources can build environmentally friendly business processes by managing and redesigning environmentally sustainable business operations for reducing the consumption of materials and energy in the organisation. Dao et al. (2011) describe how IT human resources are able to interpret business problems and address these with appropriate technical solutions. With this ability, IT personnel can redesign business processes to be more environmentally friendly, for example, by developing IS functions for automating business operations. Based on the above argument, the following hypothesis is proposed:

Hypothesis 2: IT human resource competences have a positive impact on the firm's environmental performance

3.3 Environmental IT competence

Environmental issues influence businesses' competitive landscapes in new technique. Organisations with the technology and vision to provide environmentally friendly products and services that address ecological issues will achieve a competitive edge. For example, when making purchasing, leasing or outsourcing decisions, many customers now consider the service provider's environmental record and initiatives (Murugesan, 2008). ANZ has policies for banning screensavers and retiring the energy in an efficient system (Molla et al., 2009). In addition, IT functions are easily upgraded to meet business demands. It also is able to educate employees' behaviour around reducing the energy consumption. Therefore, the adoption of IT is needed to help an organisation to build and improve its environmental competence.

With the rapid development of IT in organisations, there is an increasing need to use IT functions to improve environmental performance, including developing sustainability behaviour of human resources in an organisation (Pham et al., 2019). Adela et al. (2008) and Zientara and Zamojska (2018) argue that IS functions are able to build the commitment of employees to environmentally friendly work practices in an organisation. Ndubisi and Al-Shuridah (2019) argue that the use of IS functions can help an organisation to promote the choice of environmentally sustainable courses of actions by their employees. Molla et al. (2008) argue that eBay uses its market portal and other web

2.0 technologies to empower its internal green team, which helps concerned buyers to evaluate and select greener merchants.

Furthermore, several studies have revealed that IT environmental competence can be reached by implementing environmental strategies and policies. For example, Tom (2011) and Rubio et al. (2019) argues that environmentally friendly IT purchasing policies can be implemented by an organisation for meeting government regulations regarding the waste of electrical and electronic equipment. Furthermore, the availability of reusable IT equipment procedures can fulfil government regulations as well as reducing operating costs. Molla (2008) argues that organisations have to be concerned about their IT suppliers' environmental footprints in order to improve their environmental reputation. In the supply-chain management view, Zhu et al. (2005) and Salim et al. (2018) argue that there are pressures and drivers for implementing and adopting the ISO 14001 environmental management system (EMS) to comply with standards and to improve competitive position in the marketplace.

Environmental IT competence is also a scenario where organisations have to consider how their business operations impact on ecological factors. Environmental IT competence is being used as a new source of strategic advantage, value differentiation and intangible brand value (Liu and Atuahene-Gima, 2018). Furthermore, this competence can assist organisations to operate in compliance with environmental regulations (Adela et al., 2008) as well as international environmental requirements (Zhu et al., 2007). For this reason, environmental IT competence has emerged as an important new archetype for organisations to improve profit and market share objectives by reducing the dangers they pose to the environment (Remko, 1999; Zhu et al., 2007). Antoni and Jie (2013) examines the IT capabilities used for developing the environmental competence. They developed an ecological competence model based on previous studies of green IT and environmental performance. They also found that organisations can develop their environmental competence by employing IT capabilities that deliver sustainable value to relevant stakeholders and improves environmental performance. For example, adopting IT equipment made from non-hazardous materials can help organisations show that they take environmental matters seriously and this will enhance their reputation. The above discussion would lead to the following hypothesis:

Hypothesis 3: environmental competence of an organisation has a positive and significant impact on the firm's environmental performance

3.4 Business process digitisation

There is much research investigating the role of business process digitisation (BPD) for improving environmental performance. For example, Gholami et al. (2016) organisations with business process digitisation can make extensive and intensive use of IT for communications and business transactions in business processes to improve environmental performance. The use of computer network systems and teleconferencing technology in business operations is an essential component for linking stakeholders inside and outside organisations (Lindeblad et al., 2016). These technologies are required by organisations including ICT organisations to communicate and interact with their business units and partners on different islands. Furthermore, these technologies also can help organisations to develop 'green offices' with reduced transport costs and less energy consumption. This study has also shown that organisations can consider other types of

communications technology that can be used in many different business environments to reduce operating costs, office space and the size of the workforce.

Furthermore, Zhang and Wen (2017) explore the relationship between BPD and strategy in organisations. In this study, the internet is used as the important element in business process digitisation. Furthermore, the study utilises the innovation and efficiency approach to develop the environmental competence of organisations. With the innovation orientation, the study shows that the internet facilitates organisations in improving communication with stakeholders, to explorer large audiences. Through the efficiency orientation, the study shows that the internet can provide lower cost to market and automation of administrative processes. Therefore, organisations can use the internet to produce lower costs and more efficient and effective business operations in order to improve environmental performance.

Weill and Vitale (2002) argue that organisation with high BPD make intensive and extensive use of IT for communications, business transactions and key business processes. The use of IT for internal and external communications refers to the intensity of electronic communications media for business operations such as email, intranets and wireless devices. The use of IT for business transactions refers to a high degree of digitalisation of an organisation's repetitive transactions, particularly sales, customer interaction and purchasing. The use of IT for key business processes refers to internet-based architectures for key business functions including sales force management, employee performance measurement, training and post-sales customer support.

BPD is widely used for enhancing environmental performance. For example, the adoption of electronic procurement (e-procurement) supports reducing paper usage in business activities and improving environmental performance (Loos et al., 2011). The adoption of customer service systems with websites that provide electronic forms and e-services can reduce the costs of office space and human intervention to minimum business operation costs (De Ruyter et al., 2001). The adoption of environmental information disclosure can help an organisation to achieve pollution prevention and control with relatively lower regulatory costs. Furthermore, it can improve the environmental reputation of an organisation (worldbank.org). Adoption of web databases as document management systems helps organisations to manage their documents. In this system, documents are indexed and filed electronically and stored centrally so that every authorised user has access to them through any internet connection where they are located. With text search and optical character recognition features, retrieving documents is as quick and easy as a Google search. Therefore, employees do not need much time to go searching through file cabinets to find a file. Based on the above discussion the following hypothesis is proposed:

Hypothesis 4: Business process digitisation has a positive impact on the firm's environmental performance

Table 1 summarises the literature discussed above and proposes a research framework presented in Figure 1, which outlines the relationship between ITQ, IT human resources competence, business process digitisation, environmental IT competence and environmental performance.

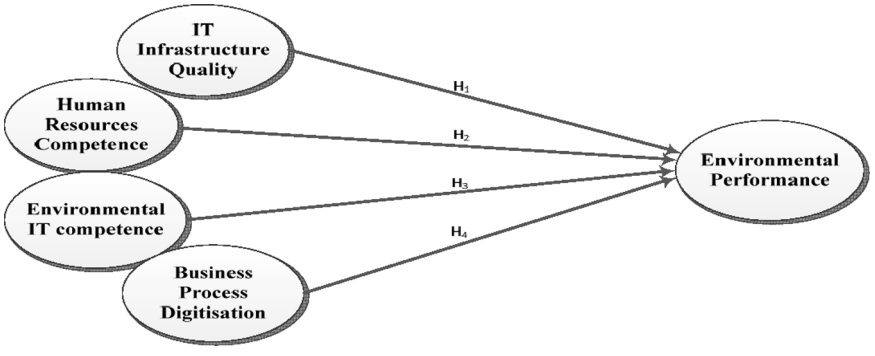
Table 1 Construct of IT infrastructure capabilities

Constructs	*Items*	*References*
IT infrastructure quality (ITQ)	1. Modularisation of information systems functions 2. Implementation of simple administration procedures and rules 3. Adoption of centralised database management systems 4. Adoption of extranets as entry points for external users 5. Adoption of virtualisation technology for improving data processing in business transactions	Antoni (2015), Duncan (1995), Loos et al. (2011), Mann et al. (2009), Molla (2009b), Molla and Abareshi (2012), Thomas et al. (2016)
IT human resources competencies (ITH)	1. Operating system competencies of IT personnel 2. Emerging technology competencies of IT personnel 3. IT personnel have the knowledge to understand the business environment that they support 4. IT personnel are able to interpret business problems and develop appropriate technical solutions 5. IT personnel have the knowledge about to identify the standardisation of IT equipment (e.g., energy star and electronic product environmental assessment tool)	Adela et al. (2008), Benitez-Amado et al. (2010), Cooper and Molla (2012), Pavlova (2017), Sayeed and Gill (2008), Speshock (2010), Wehrmeyer (2017)
Business process digitisation (BPD)	1. Adoption of teleconferencing technologies to provide integrated video and audio to connect users anywhere in the world through the internet access 2. Adoption of broadband communication networks for delivering high bandwidth applications (e.g., imaging and video conferencing) 3. Adoption of e-procurements to provide the purchase of supplies, work, and services through the internet as well as other information and networking systems 4. Adoption of document management/ archival systems to track and store electronic documents	Byrd and Turner (2000), Loos et al. (2011), Mann et al. (2009), Melville (2010), Molla (2009a), Molla et al. (2012), Murugesan (2008), Weill and Vitale (2002), Zhang and Wen (2017)

Table 1 Construct of IT infrastructure capabilities (continued)

Constructs	*Items*	*References*
Environmental IT competence	1. Top management is very concerned with green IT issues 2. The IT Vision of an organisation is clearly defined 3. Ability of IS functions to build the commitment of employees to environmentally friendly work practices in an organisation 4. Ability of IS functions to promote the choices of environmentally sustainable course of actions 5. Low-energy IT equipment is widely used in our organisation	Héroux and Fortin (2018), Molla (2009a), Sayeed and Gill (2008)
Environmental performance (EP)	1. Energy consumption 2. CO_2 emission reduction 3. Environmental management system 4. Environmental initiatives 5. Environmental disclosure	Elsayed and Paton (2005), Jacobs et al. (2010), Moneva and Ortas (2010)

Figure 1 The proposed conceptual framework



4 Research methodology

The data was collected using a questionnaire method. At the beginning of this phase, a pilot study of the instruments with a small number of participants was conducted. The purpose of the pilot study was to ensure that the questionnaire was well developed. Then the questionnaire was structured and presented on a seven-point Likert scale to facilitate examination of the relationship between the role of IT capability and organisational environmental performance. A seven-point Likert scale was used to measure the perceptions of participants in using IT capability for improving environmental performance in each organisation, which later determined the critical factors of IT capability for improving environmental performance. The sampling unit of

this study was from managerial levels in selected 1265 Indonesian ICT organisations based on the list provided by the Ministry of Trade, Republic of Indonesia. People with managerial positions are key participants in improving environmental performance (Bowen et al., 2001; Carter and Ellram, 1998; Zhu et al., 2005). We believe that managers or their equivalent are both well positioned and better informed to answer the research questions. Therefore, the respondents with managerial positions were selected using a clustering approach. Clustering was based on the regions where the ICT organisations were located. Of 1265 questionnaires sent, 404 responses were received of which 65 responses were removed due to incomplete answers. This left 339 cases for further analysis which means a response rate of 26.8%. Table 2 shows the summary of information of the respondents.

Table 2 Demographic distribution of collected data

Job Title	*Frequency*	*Percent*	*IT proficiency*	*Frequency*	*Percent*
CEO/President	22	6.5	Low	17	5
Director	12	3.5	Medium	160	47.2
Manager	81	23.9	High	162	47.8
Supervisor	59	17.4	Total	339	100
Others	165	48.7			
Total	**339**	**100**			
Firm size	*Frequency*	*Percent*	*Business type*	*Frequency*	*Percent*
1–50	94	27.7	Computer Hardware	57	16.8
51–100	70	20.6	Telecom	204	60.2
101–250	22	6.5	IT Consultant	20	5.9
251–500	8	2.4	IT Solution	37	10.9
501–1000	9	2.7	Others	21	6.2
>1001	136	40.1	Total	339	100
Total	**339**	**100**			

5 Data analysis

5.1 Measurement model

To determine the statistical validity of the survey instrument, several statistical tests were performed on the collected data. To start, an exploratory factor analysis (EFA) using Mplus 7.4 was conducted. Before undertaking the EFA, a critical stage is to evaluate the quality of the sample. Therefore, tests of sampling adequacy and sphericity were conducted. The Kaiser-Meyer-Olkin (KMO) and Bartlett's Test of Sphericity were used to assess the suitability of the respondent data for factor analysis. KMO value is 0.870 and Bartlett's Test of Sphericity with p value of 0.000 indicate that there are correlations in the dataset that are appropriate for factor analysis and the hypothesis testing (Kaiser, 1960). The objective of EFA is to identify the underlying constructs of the research. To estimate SEM models with ordinal data it is highly recommended to use the more generalised weighted least square based robust estimators. Therefore, mean adjusted

WLS estimator (WLSM) was used as the model estimation (Muthen, 2004). The results of EFA show that the items were loaded as hypothesised factors with $\chi^2 = 545.162$ with d.f = 241, *p*-value = 0, RMSEA = 0.061, WRMR = 0.827, CFI = 0.99 and TLI = 0.99 which show an acceptable model fit. A WRMR value of 1.0 or lower is considered a good fit (Yu, 2002). Raykov (1998) has demonstrated that Cronbach's alpha may over- or under-estimate scale reliability. As such, we calculate the reliability RHO to test the internal consistency of the research instrument. Minimum RHO of 0.897 indicates of the internal consistency of the instrument. The results of EFA and one factor congeneric model are shown in Table 3.

Table 3 The results of EFA and one factor congeneric model

	Mean	*Std. dev.*	*Factor loading*	*AVE*	*Construct reliability* (*RHO*)	*Goodness-of-fit*
Environmental IT competence				0.637	0.897	
EIT1	5.53	0.891	0.796			Chi square= 7.68
EIT2	5.59	0.923	0.762			*P* value = 0
EIT3	5.60	0.915	0.809			CFI = 0.99
EIT4	5.64	0.920	0.794			TLI = 0.99
EIT5	5.60	0.928	0.827			RMSEA = 0.07
Human resources competence				0.727	0.930	
ITH1	5.76	0.958	0.851			Chi square= 2.76
ITH2	5.74	0.921	0.844			*P* value = 0
ITH3	5.75	0.938	0.866			CFI = 1.00
ITH4	5.74	0.938	0.847			TLI = 0.98
ITH5	5.74	0.946	0.856			RMSEA = 0.07
Business process digitisation				0.732	0.916	
BPD1	5.62	0.960	0.779			Chi square= 7.68
BPD2	5.65	0.947	0.924			*P* value = 0
BPD3	5.63	0.944	0.877			CFI = 0.99, TLI = 0.99
BPD4	5.58	0.937	0.836			RMSEA= 0.00
IT infrastructure quality				0.733	0.932	
ITQ1	5.51	0.892	0.883			Chi square= 1.003
ITQ2	5.51	0.878	0.814			*P* value = 0
ITQ3	5.55	0.897	0.889			CFI = 1.00
ITQ4	5.54	0.901	0.860			TLI = 1.00
ITQ5	5.60	0.906	0.831			RMSEA = 0.00
Environmental performance				0.673	0.911	
ENP1	5.50	0.888	0.838			Chi Square= 7.68
ENP2	5.53	0.885	0.800			P value = 0
ENP3	5.51	0.892	0.903			CFI = 0.99
ENP4	5.52	0.885	0.751			TLI = 0.99
ENP5	5.57	0.896	0.803			RMSEA = 0.07

In addition, this study performed Harman's single factor test with all indicators used in this study. A total of five factors were extracted. The first factor explains 34.3% of the variance which suggests that common method bias is not a major concern in this study (Podsakoff et al., 2003).

To ensure of quality of measurement, a confirmatory factor analysis (CFA) was employed to assess the reliability and validity of construct. CFA is a way of testing how well measured variables represent a number of constructs (Hair et al., 2010). As seen in Table 4, the average variance extracted (AVE) for all factors are greater than 0.5, implying convergent validity of the measurement indexes. AVE estimates for two factors should be greater than the square of the correlation between the two factors to provide evidence of discriminant validity (Hair et al., 2010). As shown in Table 4, AVE values are greater than squared correlation among constructs which indicates discriminant validity.

Table 4 Results of convergent and discriminant validity analysis

	Env. IT competence	*HR competence*	*BP digitisation*	*IT infr. quality*	*Env. performance*
Env. IT competence	***0.637***	0.312	0.411	0.144	0.366
HR competence	0.559	***0.727***	0.185	0.116	0.286
BP digitisation	0.641	0.430	***0.732***	0.203	0.272
IT infr. quality	0.379	0.341	0.451	***0.733***	0.484
Env. performance	0.605	0.535	0.522	0.696	***0.673***

Values on the diagonal (bold font) represent average variance extracted. Values above the diagonal (italic font) represent the inter-construct squared correlations. Values under the diagonal represent the inter-construct correlations.

An estimated model of critical factors in information technology capability and environmental performance was devised based the results of measurement model. Four constructs were evaluated in the proposed theoretical framework: environmental IT competence, human resources competence, BPD, and ITQ. Testing the causal model's goodness of fit yielded the following results: χ^2 (241) = 545.162, p-value = 0.00, CFI = 0.994, TLI = 0.993, and WRMR value of 0.827 and RMSEA = 0.061 with 90% C.I. between 0.054 and 0.068. The results of model fit indices indicate of an acceptable model's fitness to the collected data. After confirming the fitness of the model, this study processed to the hypotheses testing.

Table 5 shows the estimates of path coefficients for the proposed model. The Environmental IT competence (estimate 0.29, $p = 0.00$), IT human resources competence (estimate 0.19, $p = 0.00$), and ITQ (estimate 0.51, $p = 0.00$) were found to have significant relationship to firms' environmental performance. In the meantime, Business process digitisation (estimate 0.024, $p = 0.664$) did not show a significant impact on firms' environmental performance. The model explains 65.5% of the variances in the firms' environmental performance.

Table 5 Hypotheses testing for hypothesised structural model

Factors			*Standardised estimates*	*P value*	*Outcome*
IT infrastructure quality	⇒	Environmental performance	0.511	0.000	Accepted
IT human resources competence	⇒	Environmental performance	0.188	0.000	Accepted
Environmental IT competence	⇒	Environmental performance	0.290	0.000	Accepted
Business process digitisation	⇒	Environmental performance	0.024	0.664	Rejected

6 Discussion

The use of IT capability in improving environmental performance is relatively new to the field of information system research. Organisations with the IT and vision to provide products and services that address environmental issues will achieve a competitive edge. One reason is that when making decisions about purchasing, leasing or outsourcing, many customers now take into account the environmental initiatives of the provider of products or services (Murugesan, 2008). Therefore, businesses need to consider using IT in ways that develop and improve their environmental competence.

In this study, energy consumption reduction is focused on building efficiency of business operations. Furthermore, this can be achieved by using IT and IS to automate business activities and reduce human interventions in environmental protection process. In addition, energy consumption is also about how the embedding of IT capability enhances information processing in business operations. In terms of environmental management systems (EMSs), information technology has been employed to help organisations to improve their environmental performance and perform environmental management. EMS is one of indicator of how the organisation manages business processes including material flows, life cycle assessments, legal databases, government effluent monitoring, and environmental knowledge sources. EMS is determined by the extent to which this indicator is important in managing the business processes of an organisation. For example, the use of personal computers, servers and workstations are used for air emission monitoring and wastewater sensors.

The environmental initiatives of an organisation are about the extra effort that an organisation takes for improving its environmental performance through adopting IT capability in addition to meeting the basic environmental compliance requirements. For example, adopting green IT practices offers organisations with business and individual financial benefits through redesigning and replacing their IT products and services with environmentally friendly IT products designed to make their business operations greener for the long term. Another example is Apple Inc. that has an initiative solution at maximising energy efficiency through reducing and eliminating toxic chemicals present in their new products and more aggressively recycling its old products.

The environmental reputation of an organisation is related to the environmentally friendly image that the organisation wants to project to the public of its overall commitment towards environmentally sustainable operations (Van Passel et al., 2007). With the increasing demand on organisations for sustainable developments, organisations begin to adopt various approaches for establishing and promoting themselves as environmentally responsible citizens in the community. For example, businesses use

sustainability and corporate social responsibility initiatives such as green supply chain management, environmentally preferable business practices; environmentally friendly technologies, and an aggressive stance towards CO_2 emissions to demonstrate their commitment to the environment (McWilliams et al., 2006). Returns from such initiatives include building positive brand image, mitigating any environmental liabilities associated with a firm's products and services and influencing the mindset of customers and investors (Rao and Holt, 2005; Sen et al., 2006). Consumer buying habits are increasingly driven by ethical concerns. Green issues may not only have an impact on consumer buying power, but also affect how both the public and private sector award competitive tenders (Cooper and Molla, 2012).

Descriptive findings of this research indicate that the adoption of centralised database management systems, modularisation of information systems functions and storage and desktop virtualisations builds a well-integrated platform that allows Indonesian ICT organisations to run a virtual business online like conducting real-time business transactions via communications and computer networks. This was also evident in Vazquez et al. (2011) study, which found that with an increase in virtual technologies, organisations have opportunities to build business processes effectively and efficiently.

The acceptance of Hypothesis 1 suggests that the critical components of ITQ, such as the adoption of database management systems, storage virtualisation and implementation of simple administration procedures and rules lead to improved environmental performance as manifested in term of a EMS, environmental initiatives, environmental disclosure, and organisational environment reputations in a developing economic country such as Indonesia. This is very important for Indonesia as one of the largest countries in the world is one of the world's most vulnerable countries to natural disasters. This is because Indonesia is located on the pacific ring of fire that is subject to the constant risk of volcanic eruptions, earthquakes, tsunamis and floods. In the last 15 years, Indonesia has endured devastating natural disasters that have resulted in the deaths of hundreds of thousands of people and have had destructive effects on the country's infrastructure (Indonesia, 2012). Furthermore, this also affects the economic and business environment in Indonesia. Based on the World Bank (2011), the economic impact of the 2004 earthquake in Aceh was estimated at US$ 4.5 billion dollars. Likewise, in 2006, the earthquake in Yogyakarta caused an economic impact of US$ 3.5 billion dollars. Surprisingly, virtual technologies including server, storage and desktop virtualisation have been found to be the best technologies for disaster recovery in business processes because of their high resource utilisation, high availability, and recovery management and dynamic infrastructure (Sindoori et al., 2012). Disaster recovery is the process in business operations of organisations that can recover data after any catastrophic events occurs. The finding is also consistent with Gmach and Holcomb's (2004) study finding that these technologies when implemented in organisational business processes with more empowerment showed significant improvement in reducing process recovery. This current finding also agrees with Kovar (2008), Hoopes (2009) and Delahunty's (2011) study findings; that is, that virtualisation technologies are essential infrastructure in business processes when disasters occur because they are easy to set up and configure in problem areas.

As most islands in Indonesia, such as Sumatra, Borneo, Sulawesi and West Papua, have electricity supply issues, with these virtualisation technologies, ICT organisations have solutions for operating their business activities through placing their information and database systems with overseas or domestic internet service providers that have the

capacities to overcome these problems for operating business processes. The finding is consistent with that of Marston et al. (2011) that the concept of virtualisation technologies embraces the ideas encapsulated in green computing, since not only are the computing resources used more efficiently, but further, the computers can be physically located in geographical areas that have access to no electricity supply while their computing power can be accessed long distances away over the internet. This current finding also agrees with those of Wittow and Buller (2010) and Kloch et al. (2011); that is, that virtualisation technologies allow organisations to access their data anywhere and anytime through the internet to deliver computer performance required business activities including telecommunications and transactions.

Hypotheses testing also shows that IT human resources competence has a significant positive effect on environmental performance (H2). It emphasises the vital role of human resources in leveraging IT capabilities. In Indonesian ICT circumstances, the competence of IT human resources in environmental government regulations, management system standards (ISO) and standardisation of IT equipment can help organisations as guidelines in business processes to select suppliers, raw material and products with the objective of minimising the environmental impact of their business activities (PT Bakrie Telecom, 2012). For example, PT Telkom has implemented the standardisation of IT equipment in its business processes to facilitate the development of governance process and documentation systems in order to develop environmental capabilities. Further, ICT organisations have identified 'green' suppliers based on government reports and international independent organisations addressing the environmental issues for building environmental business operations. Therefore, a combination of IT human resources competence and business process digitisation is required for the Indonesian ICT industry to develop environmental IT competence of IT in their organisational business operations.

In Hypothesis 3, Environmental IT competence was hypothesised to influence the environmental performance of an organisation. It focuses on the firms IT vision on green IT issues and IT functions in promoting sustainable strategies. The current finding endorses previous environmental performance studies that have identified the effects of environmental IT competence on environmental performance. Chou and Chou (2012) found that organisations must create environmental policies and procedures to guide employees' working behaviour and methods. Reusable and disposal IT equipment policies are required as part of organisations' social responsibility to deal and meet with local government and international independent organisations (Vazquez et al., 2011). This finding is in line with that of Rubio et al. (2019) who states and conceptually argues that environmental policies cover the work that an organisation has done to support EMSs in daily business operations. This finding is also consistent with RBV-based studies in IS, which found that environmental policies are embedded in a bundle of green capability to enable and support environmental initiatives across the significant areas of sourcing, operations and services in order to improve the environmental reputation of organisation (Dubey et al., 2019).

Our findings show that the sustainability behaviour of employees is influenced by the capabilities of IS that can build and change their commitment to environmentally friendly work practices and promote the choice of environmentally sustainable courses of actions. This finding is related to that of Gholami et al. (2013), who found that IS adoption has a significant relationship with environmental performance. This is also consistent with Butler and McGovern (2009) argument about IS having the ability to help organisations

provide an annual sustainability report that is required by local government and global regulators. Likewise, the finding supports the theoretical finding of Tom (2011) regarding the importance of the ability of IS adoption to improve the environmental reputations of organisations.

The finding of a relationship between environmental IT competence and environmental performance implies the importance of resource stewardship for organisational environmental performance in business operations. In this case, organisations in reducing the impact of their business activities on the natural environment should implement and adopt IS functions that consider the IT life management. For example, Dell computers provide information systems to facilitate customers in recycling and disposing of their product in an environmentally friendly manner (Loos et al., 2011).

7 Conclusion and limitations

This research investigated the critical factors involved in IT capability for developing environmental competence in Indonesian ICT organisations from the perspective of IT-related human resource competencies and infrastructure. The hypothesised framework is developed based on a review of the literature on RBV theory and green IT. The framework is validated using SEM based on survey data collected in Indonesia. It is evident that environmental performance is influenced by ITQ, IT human resources competence, and environmental IT competence. There are some limitations in this study: First, this research focused only on the ICT industry in Indonesia. It may raise questions about the limited external validity and could limit the generalisability of the findings. Second, this research was conducted as a cross-sectional study. Future research might consider a longitudinal study to investigate the impact of the underlying factor on environmental performance over time. Furthermore, the survey respondents were all IT managers. As such, their responses could lack the required level of impartiality, that is, they may have had a tendency to favourably assess the IT capability of their organisations.

References

Adela, J.W.C., Marie-Claude, B. and Richard, T.W. (2008) 'Information systems and ecological sustainability', *Journal of Systems and Information Technology*, Vol. 10, No. 3, pp.186–201.

Antoni, D. (2015) 'Critical factors of information technology infrastructure quality for enhancing environmental competencies of the Indonesian organizations', *JURNAL MATRIK*, Vol. 17, No. 2, pp.133–150.

Antoni, D. and Jie, F. (2012) 'The relationship between IT capability and organizational environment performance: a conceptual framework', *3rd Annual International Conference on Infocomm Technologies in Competitives Strategies (ICT 2012)*, Bali, Indonesia, p.47.

Antoni, D. and Jie, F. (2013) 'Investigating the critical capabilities of information technology for developing ecological competencies of organizations', Paper presented at the *11th ANZAM Operations, Supply Chain and Services Management Symposium*, Brisbane, Australia.

Bank, T.W. (2011) *Indonesia Advancing a National Disaster Risk Financing Strategy-Options for Consideration*, Retrieved from Washington, USA, www.worldbank.org

Barney, J. (1991) 'Firm resources and sustained competitive advantage', *Journal of Management*, Vol. 17, No. 1, pp.99–120, doi: 10.1177/014920639101700108.

Benitez-Amado, J., Perez-Arostegui, M.N. and Tamayo-Torres, J. (2010) 'Information technology enabled innovativeness and green capabilities', *The Journal of Computer Information Systems*, Vol. 51, No. 2, pp.87–96.

Bharadwaj, A.S. (2000) 'A resource-based perspective on information technology capability and firm performance: an empirical investigation', *MIS Quarterly*, Vol. 24, No. 1, pp.169–196.

Bowen, F.E., Cousins, P.D., Lamming, R.C. and Farukt, A.C. (2001) 'The role of supply management capabilities in green supply', *Production and Operations Management*, Vol. 10, No. 2, pp.174–189, doi: 10.1111/j.1937-5956.2001.tb00077.x.

Broadbent, M. and Weill, P. (1997) 'Management by maxim: how business and IT managers can create IT infrastructures', *MIT Sloan Management Review*, Vol. 38, No. 3, pp.77–92.

Broadbent, M., Weill, P. and Neo, B.S. (1999) 'Strategic context and patterns of IT infrastructure capability', *The Journal of Strategic Information Systems*, Vol. 8, No. 2, pp.157–187.

Butler, T. and McGovern, D. (2009) 'A conceptual model and IS framework for the design and adoption of environmental compliance management systems', *Information Systems Frontiers*, pp.1–15, doi: 10.1007/s10796-009-9197-5.

Byrd, T.A. and Turner, D.E. (2000) 'Measuring the flexibility of information technology infrastructure: exploratory analysis of a construct', *Journal of Management Information Systems*, Vol. 17, No. 1, pp.167–208.

Carter, C. and Ellram, L. (1998) 'Reverse logistics: a review of the literature and framework for future investigation', *Journal of Business Logistics*, Vol. 19, No. 1, pp.85–102.

Chaudhuri, S., Dayal, U. and Narasayya, V. (2011) 'An overview of business intelligence technology', *Communications of the ACM*, Vol. 54, No. 8, pp.88–98.

Chou, D.C. and Chou, A.Y. (2012) 'Awareness of green IT and its value model', *Computer Standards & Interfaces*, Vol. 34, No. 5, pp.447–451, doi: http://dx.doi:org/10.1016/j.csi.2012.03.001.

Cooper, V.A. and Molla, A. (2012) 'Developing green IT capability: an absorptive capacity perspective', Paper presented at the *Pacific Asia Conference on Information Systems*, Ho Chi Minh, Vietnam, pp.46–61.

Dao, V., Langella, I. and Carbo, J. (2011) 'From green to sustainability: information technology and an integrated sustainability framework', *The Journal of Strategic Information Systems*, Vol. 20, No. 1, pp.63–79.

Day, G.S. (1994) 'The capabilities of market-driven organizations', *The Journal of Marketing*, Vol. 54, No. 4, pp.37–52.

De Ruyter, K., Wetzels, M. and Kleijnen, M. (2001) 'Customer adoption of e-service: an experimental study', *International Journal of Service Industry Management*, Vol. 12, No. 2, pp.184–207.

Delahunty, S. (2011) 'Server virtualization', *InformationWeek*, 1 August, 2011, p.8.

Dubey, R., Gunasekaran, A., Childe, S.J., Papadopoulos, T., Luo, Z., Wamba, S.F. and Roubaud, D. (2019) 'Can big data and predictive analytics improve social and environmental sustainability?', *Technological Forecasting and Social Change*, Vol. 144, pp.534–545.

Duncan, N.B. (1995) 'Capturing flexibility of information technology infrastructure: a study of resource characteristics and their measure', *Journal of Management Information Systems*, Vol. 12, No. 2, pp.37–37.

Elsayed, K. and Paton, D. (2005) 'The impact of environmental performance on firm performance: static and dynamic panel data evidence', *Structural Change and Economic Dynamics*, Vol. 16, No. 3, pp.395–412.

Fürst, E. and Oberhofer, P. (2012) 'Greening road freight transport: evidence from an empirical project in Austria', *J. Clean. Prod.*, Vol. 33, pp.67–73.

Gholami, R., Sulaiman, A.B., Ramayah, T. and Molla, A. (2013) 'Senior managers' perception on green information systems (IS) adoption and environmental performance: results from a field survey', *Information & Management*, Vol. 50, No. 7, pp.431–438, doi: 10.1016/j.im.2013.01.004.

Gholami, R., Watson, R.T., Molla, A., Hasan, H. and Bjørn-Andersen, N. (2016) 'Information systems solutions for environmental sustainability: How can we do more?', *Journal of the Association for Information Systems*, Vol. 17, No. 8, p.521.

Gmach, J. and Holcomb, T. (2004) 'Server virtualization, Article', *Computer Technology Review*, p.37+, Retrieved from http://go.galegroup.com/ps/i.do?id=GALE%7CA123332249&v=2.1&u=rmit&it=r&p=AONE&sw=w&asid=b3b2b8d26ebe99333f7cffdbefc348ac

Hair, J.F., Tatham, R.L., Anderson, R.E. and Black, W. (2010) *Multivariate Data Analysis*, Vol. 7, Pearson Prentice Hall, Upper Saddle River, NJ.

Harmon, R.R. and Auseklis, N. (2009) 'Sustainable IT services: assessing the impact of green computing practices', Paper presented at the *Management of Engineering & Technology, 2009. PICMET 2009, Portland International Conference on Management of Engineering & Technology*, IEEE, pp.1707–1717.

Héroux, S. and Fortin, A. (2018) 'The moderating role of IT-business alignment in the relationship between IT governance, IT competence, and innovation', *Information Systems Management*, Vol. 35, No. 2, pp.98–123.

Hoopes, J. (2009) *Virtualization for Security: Including Sandboxing, Disaster Recovery, High Availability, Forensic Analysis and Honeypotting*, Syngress, USA.

Indonesia, B.N.P.B. (2012) *Potensi Ancaman Bencana, Pusat Data Informasi dan Humas Badan Nasional Penanggulangan Bencana Indonesia*, Jakarta, Retrieved from http://www.bnpb.go.id/

Jacobs, B.W., Singhal, V.R. and Subramanian, R. (2010) 'An empirical investigation of environmental performance and the market value of the firm', *Journal of Operations Management*, Vol. 28, No. 5, pp.430–441.

Jänicke, M. (2008) 'Ecological modernisation: new perspectives', *Journal of Cleaner Production*, Vol. 16, No. 5, pp.557–565.

Jenkins, H. and Yakovleva, N. (2006) 'Corporate social responsibility in the mining industry: exploring trends in social and environmental disclosure', *Journal of Cleaner Production*, Vol. 14, pp.271–284.

Jiao, H., Chang, I.C. and Lu, Y. (2008) 'The relationship on ınformation technology capability and performance: an empirical research in the context of China's Yangtze River Delta region', *2008 IEEE International Conference on Industrial Engineering and Engineering Management*, IEEE, pp.872–876.

Kaiser, H.F. (1960) 'The application of electronic computers to factor analysis', *Educational and Psychological Measurement*, Vol. 20, No. 1, pp.141–151.

Kettinger, W.J., Grover, V., Guha, S. and Segars, A.H. (1994) 'Strategic information systems revisited: a study in sustainability and performance', *MIS Quarterly*, Vol. 18, No. 1, pp.31–58.

Kloch, C., Petersen, E.B. and Madsen, O.B. (2011) 'Cloud based infrastructure, the new business possibilities and barriers', *Wireless Personal Communications*, Vol. 58, No. 1, pp.17–30.

Kovar, J.F. (2008) 'Midmarket storage and disaster recovery – no time to lose – make use of server virtualization to protect clients' environments', *CRN*, Jericho, Vol. 1258, p.32.

Lindeblad, P.A., Voytenko, Y., Mont, O. and Arnfalk, P. (2016) 'Organisational effects of virtual meetings', *Journal of Cleaner Production*, Vol. 123, pp.113–123.

Liu, S. (2002) 'A practical framework for discussing IT infrastructure', *IT Professional*, Vol. 4, No. 4, pp.14–21.

Liu, W. and Atuahene-Gima, K. (2018) 'Enhancing product innovation performance in a dysfunctional competitive environment: the roles of competitive strategies and market-based assets', *Industrial Marketing Management*, Vol. 73, pp.7–20.

Loos, P., Nebel, W., Gómez, J.M., Hasan, H., Watson, R.T., vom Brocke, J. and Recker, J.C. (2011) 'Green IT: a matter of business and information systems engineering?', *Business and Information Systems Engineering*, Vol. 3, pp.245–252.

Luftman, J. (2003) *Managing the Information Technology Resource: Leadership in the Information Age*, Pearson Education, Upper Saddle River, NJ.

Mann, H., Grant, G. and Singh, I. (2009) 'Green IT: an implementation framework', *AMCIS 2009 Proceedings*, San Francisco, California, p.121.

Marston, S., Li, Z., Bandyopadhyay, S., Zhang, J. and Ghalsasi, A. (2011) 'Cloud computing – the business perspective', *Decision Support Systems*, Vol. 51, No. 1, pp.176–189.

McKendrick, J. (2010) 'Database virtualization: new approach rapidly on the rise (Research@DBTA)', *Database Trends & Applications*, Vol. 24, No. 1, pp.2-2.

McWilliams, A., Siegel, D.S. and Wright, P.M. (2006) 'Corporate social responsibility: strategic implications', *Journal of Management Studies*, Vol. 43, No. 1, pp.1–18.

Melville, N. (2010) 'Information systems innovation for environmental sustainability', *MIS Quarterly*, Vol. 34, No. 1, pp.1–21.

Molla, A. (2008) 'GITAM: a model for the adoption of green IT', Paper presented at the *19th Australasian Conference on Information Systems*, 3–5 December, Christchurch, New Zealand, pp.658–668.

Molla, A. (2009a) 'Organizational motivations for green IT: exploring green IT matrix and motivation models', *PACIS 2009 Proceeding*, Hyderabad, India, pp.1–14.

Molla, A. (2009b) 'The reach and richness of green IT: a principal component analysis', Paper presented at the *20th Australasian Conference on Information Systems*, 2–4 December, Melbourne, Australia, pp.754–764.

Molla, A. and Abareshi, A. (2012) 'Organizational green motivations for information technology: empirical study', *Journal of Computer Information Systems*, Vol. 52, No. 3, pp.92–102.

Molla, A., Cooper, V., Corbitt, B., Deng, H., Peszynski, K., Pittayachawan, S. and Teoh, S. (2008) 'E-readiness to G-readiness: developing a green information technology readiness framework', Paper presented at the *19th Australasian Conference on Information Systems*, 3–5 December, Christchurch, New Zealand, p.35.

Molla, A., Cooper, V.A. and Pittayachawan, S. (2009) 'IT and eco-sustainability: developing and validating a green IT readiness model', Paper presented at the *ICIS 2009 Proceedings*, Phoenix, Arizona, USA, p.141.

Moneva, J.M. and Ortas, E. (2010) 'Corporate environmental and financial performance: a multivariate approach', *Industrial Management & Data Systems*, Vol. 110, No. 2, pp.193–210.

Murugesan, S. (2008) 'Harnessing green IT: principles and practices', *IT Professional Magazine*, Vol. 10, No. 1, pp.24–33, doi: 10.1109/mitp.2008.10

Muthen, B.O. (2004) 'Latent variable analysis: growth mixture modeling and related techniques for longitudinal data', in Kaplan, D. (Ed.): *Handbook of Quantitative Methodology for the Social Sciences*, Sage, Newbury Park, CA, pp.345–368.

Nagarajan, A. and White, C. (2008) 'Logistics', in Macher, J.T. and Mowery, D.C. (Eds.): *Innovation in Global Industries: US Firms Competing in a New World: Collected Studies*, National Academy Press, Washington, DC., USA.

Ndubisi, N.O. and Al-Shuridah, O. (2019) 'Organizational mindfulness, mindful organizing, and environmental and resource sustainability', *Business Strategy and the Environment*, Vol. 28, No. 3, pp.436–446.

Olsthoorn, X., Tyteca, D., Wehrmeyer, W. and Wagner, M. (2001) 'Environmental indicators for business: a review of the literature and standardisation methods', *Journal of Cleaner Production*, Vol. 9, No. 5, pp.453–463.

Pavlova, M. (2017) 'Green skills as the agenda for the competence movement in vocational and professional education', *Competence-Based Vocational and Professional Education*, Springer, Cham, pp.931–951.

Pham, N.T., Tučková, Z. and Jabbour, C.J.C. (2019) 'Greening the hospitality industry: how do green human resource management practices influence organizational citizenship behavior in hotels? A mixed-methods study', *Tourism Management*, Vol. 72, pp.386–399.

Podsakoff, P.M., MacKenzie, S.B., Lee, J.Y. and Podsakoff, N.P. (2003) 'Common method biases in behavioral research: a critical review of the literature and recommended remedies', *Journal of Applied Psychology*, Vol. 88, No. 5, p.879.

Porter, M.E. and Van der Linde, C. (1995) 'Green and competitive: ending the stalemate', *Harvard Business Review*, Vol. 73, No. 5, pp.120–134.

Powell, T.C. and Dent-Micallef, A. (1997) 'Information technology as competitive advantage: the role of human, business, and technology resources', *Strategic Management Journal*, Vol. 18, No. 5, pp.375–405.

PT Bakrie Telecom, I. (2012) *Penerapan Ekonomi Hijau Bakrie Telecom*, Retrieved from http://www.bakrietelecom.com/bakrie-telecom-selenggarakan-ict-green-asia

Rao, P. and Holt, D. (2005), 'Do green supply chains lead to competitiveness and economic performance?', *International Journal of Operations & Production Management*, Vol. 25, No. 9, pp.898–916.

Raykov, T. (1998) 'Coefficient alpha and composite reliability with interrelated nonhomogeneous items', *Applied Psychological Measurement*, Vol. 22, No. 4, pp.375–385.

Remko, I.v.H. (1999) 'From reversed logistics to green supply chains', *Supply Chain Management: An International Journal*, Vol. 4, No. 3, pp.129–135.

Rubio, S., Ramos, T.R.P., Leitão, M.M.R. and Barbosa-Povoa, A.P. (2019) 'Effectiveness of extended producer responsibility policies implementation: the case of Portuguese and Spanish packaging waste systems', *Journal of Cleaner Production*, Vol. 210, pp.217–230.

Salim, H.K., Padfield, R., Yuzir, A., Mohamad, S.E., Kaida, N., Papargyropoulou, E. and Nakamura, S. (2018) 'Evaluating the organizational intention to implement an environmental management system: evidence from the Indonesian food and beverage industry', *Business Strategy and the Environment*, Vol. 27, No. 8, pp.1385–1398.

Sayeed, L. and Gill, S. (2008) 'An exploratory study on environmental sustainability and IT use', Paper presented at the *AMCIS 2008 Proceedings*, 14–17 August, Toronto, Canada, p.55.

Sen, A.K., Darabi, J., Knapp, D.R. and Liu, J. (2006) 'Modeling and characterization of a carbon fiber emitter for electrospray ionization', *Journal of Micromechanics and Microengineering*, Vol. 16, No. 3, p.620.

Sindoori, R., Pallavi, V.P. and Abinaya, P. (2012) 'An overview of disaster recovery in virtualization technology', *J. Artificial Intelligence*, Vol. 6, pp.60–67.

Singh, R.K., Murty, H.R., Gupta, S.K. and Dikshit, A.K. (2009) 'An overview of sustainability assessment methodologies', *Ecological Indicators*, Vol. 9, No. 2, pp.189–212.

Speshock, C. (2010) *Empowering Green Initiatives with IT: A Strategy and Implementation Guide*, Wiley, USA.

Thomas, M., Costa, D. and Oliveira, T. (2016) 'Assessing the role of IT-enabled process virtualization on green IT adoption', *Information Systems Frontiers*, Vol. 18, No. 4, pp.693–710.

Tippins, M.J. and Sohi, R.S. (2003) 'IT competency and firm performance: is organizational learning a missing link?', *Strategic Management Journal*, Vol. 24, No. 8, pp.745–761, doi: 10.1002/smj.337.

Tom, B. (2011) 'Compliance with institutional imperatives on environmental sustainability: building theory on the role of green IS', *The Journal of Strategic Information Systems*, Vol. 20, No. 1, pp.6–26.

Van Passel, S., Nevens, F., Mathijs, E. and Van Huylenbroeck, G. (2007) 'Measuring farm sustainability and explaining differences in sustainable efficiency', *Ecological Economics*, Vol. 62, No. 1, pp.149–161.

Vazquez, R., Rocha, E., Dominguez, S., Morales, D. and Ahluwalia, P. (2011) 'Green IS and green IT: organizational awareness, readiness and competitiveness', *AMCIS 2011 Proceedings*, Detroit, USA, Paper 443.

Wang, Y., Rodrigues, V.S. and Evans, L. (2015) 'The use of ICT in road freight transport for CO_2 reduction – an exploratory study of UK's grocery retail industry', *The International Journal of Logistics Management*, Vol. 26, No. 1, pp.2–29.

Watson, R.T., Boudreau, M-C. and Chen, A.J. (2010) 'Information systems and environmentally sustainable development: energy informatics and new directions for the IS community', *MIS Quarterly*, Vol. 34, No. 1, pp.23–38.

Wehrmeyer, W. (2017) *Greening People: Human Resources and Environmental Management*, Routledge, London, UK.

Weill, P. and Vitale, M. (2002) 'What it infrastructure capabilities are needed to implement e-business models?', *MIS Quarterly*, Vol. 1, No. 1, pp.17–17.

Wernerfelt, B. (1984) 'A resource-based view of the firm', *Strategic Management Journal*, Vol. 5, No. 2, pp.171–180.

Wittow, M.H. and Buller, D.J. (2010) 'Cloud computing: emerging legal issues for access to data, anywhere, anytime', *Journal of Internet Law*, Vol. 14, No. 1, pp.1–10.

Yu, C-Y. (2002) *Evaluating Cutoff Criteria of Model Fit Indices for Latent Variable Models with Binary and Continuous Outcomes*, University of California, Los Angeles.

Zhang, Y. and Wen, J. (2017) 'The IoT electric business model: using blockchain technology for the internet of things', *Peer-to-Peer Networking and Applications*, Vol. 10, No. 4, pp.983–994.

Zhu, Q., Sarkis, J. and Geng, Y. (2005) 'Green supply chain management in China: pressures, practices and performance', *International Journal of Operations & Production Management*, Vol. 25, Nos. 5–6, p.449.

Zhu, Q., Sarkis, J. and Lai, K. (2007) 'Green supply chain management: pressures, practices and performance within the Chinese automobile industry', *Journal of Cleaner Production*, Vol. 15, Nos. 11–12, pp.1041–1052.

Zientara, P. and Zamojska, A. (2018) 'Green organizational climates and employee pro-environmental behaviour in the hotel industry', *Journal of Sustainable Tourism*, Vol. 26, No. 7, pp.1142–1159.