GREEN IT/S ADOPTION WITHIN GSCM IN INDONESIAN CONSTRUCTION INDUSTRY: AN ELUCIDATION AND PRACTICE

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Abstract: In the current globalized and competitive economy, the adoption of information technology and information system (IT/S) is turning out to be pivotal in supply chain management (SCM). IT/S as a potent tool holds a vital role for effective control of today's complex supply chain in the organization and leads to the better supply chain performance. Hence, the IT/S usage level has been increased significantly in response to its necessity in today's global business environment. As consequence of this condition, IT/S substantially contributes to environmental problem and ecological sustainability. Even though IT/S is beneficially to the organization but basically IT/S has negative impacts to environment from its production, use, to disposal. The use of IT/S consumed not less energy, generated footprint emission, and disposed large amount of e-waste. In contrary to its perilous effect, IT/S is offering promising potential to reverse its negative impact to environment by going green and using IT application its self to greening the supply chain activities. These are termed as Green IT and Green IS (IT for green). However, the existing studies are still limited that assess the role of IT/S adoption in helping the organization to meet the sustainability goals in the whole supply chain process. Moreover, the elucidation and practicality of green IT/S its self are still unclear even green IT/S is starting implemented in several different contexts. To address this situation, this study clarifies green IT/S by interpreting it through comprehensive review of literatures. This study also provides description of potential practicality adoption of green IT/S within green supply chain management (GSCM) where the outcome will contribute to strengthening the supply chain sustainability performance, especially in the context of construction industry in Indonesia.
Keywords: Green IT/S, GSCM, Construction Industry
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Introduction

Nowadays, the organization is necessitated to be more flexible in adapting and responding to the market changes since the rapid changing and dynamic global business environment. However, current business condition is not only urged the organization in the market competition but also environmental protection or earth's sustainability (Chou & Chou, 2012). The disintegration of the earth or environmental degradation are identified by the emergence of global warming, climate change, and natural disasters has raised the level of environmental awareness and the importance of environmental protection. Organizations are getting aware of the necessity of sustainability in performing and managing work (Siedel, Recker, Pimmer, & von Brocke, 2010). Organizations have increasingly concerned about their negative impacts to the environment from their business operation activities since the environmental impacts occur in the entire supply chain and across all stages of product's life cycle. Thus, in an exertion to this, various companies have adopted GSCM practices for aid in greening the supply chain operation activities.

Meanwhile, in managing the effective supply chain, IT/S plays the vital role. IT/S usage is considered as a prerequisite for controlling today's complex supply chain. Nowadays, IT/S is regarded as a prerequisite of competitiveness, not an option to the source of competitive advantage (Li, Yang, Sun, & Sohal, 2009). Hence, the IT/S usage level has been increased significantly in response to its necessity in today's global business environment. This condition has undoubtedly contributed to the environmental problem and ecological sustainability since IT/S usage consume an immense amount of natural resources, use not less energy to power them, generated footprint emission, and disposed significant amount of e-waste (Elliot & Binney, 2008; Hedwig, et al., 2009). Recently, IT practitioners and researchers are more focused than ever on reducing the direct impact of IT/S usage has on the environment. As stated by Taha-Ijab, Molla, and Cooper (2011), the role and contribution of IT/S to the sustainability has become the concern of the researchers. IT/S communities around the globe have begun to look seriously at the role IT/S that can play in both creating and reducing environmental impacts (Raisinghani & Idemudia, 2016). As a result, integrating environmental concern into IT/S has also become pivotal for organizations' competitiveness while gaining ecological sustainability. Adding the "green" component into IT/S which term as green IT/S holds the promise as a tool in eradicating its negative environmental impacts and greening other business operation activities. SCM, IT/S and environmental sustainability have interconnected relationship and complement each other that must not be disregarded (Elliot & Binney, 2008; Zhu, Sarkis, & Lai, 2008). Besides, previous studies mentioned that holistic approach which integrate different company resources is required in developing the sustainability capabilities (Bengtsson & Agerfalk, 2011; Dao, Langella, & Carbo, 2011). Therefore, green IT/S is necessity in GSCM to achieve sustainability outcome.

However, the existing studies are still limited that assess the role of IT/S adoption in helping the organization to meet the sustainability goals in the whole supply chain process. The elucidation and practicality of green IT/S its self is still unclear in literature since green IT/S is a relatively recent phenomenon. Green IT/S have begun to be implemented in several different industry contexts such as in manufacturing industry that have been widely explored. Yet, green IT/S literature still have been neglected in such endeavours, especially in construction industry context. In fact, construction activities have significant adverse impacts to the environment and has been widely recognized from the past to the present. Construction sector is considered as a major contributor to the environmental problems (Augenbroe &

Pearce, 1998; Ofori, Briffet, Gang, & Ranasinghe, 2000; Abduh, Soemardi, & Cakravastia, 2013; Ojo, Mbohwa, & Akinlabi, 2014). Accordingly, construction industry should be get more attention and concern from both practitioners and researchers to tackle this issue by integrating the potential of green IT/S. Moreover, the biggest disincentive in adopting green IT/S, which is cost and gained business value still have been obscurity in previous studies. Indeed, much remains to be explored about the role played by IT/S in the worldwide pursuit of ecological sustainability. Thus, as an effort to address this situation, this study elucidates green IT/S by interpreting it through comprehensive review of literatures. This study also provides description of potential practicality adoption of green IT/S within green supply chain management (GSCM) where the outcome will contribute to strengthening the organization's supply chain sustainability performance especially in the context of construction industry.

Issues of the study

Construction industry has been recognized as a major contributor to environmental problems. The whole supply chain from the production of construction material, procurement of construction material, transportation and storage of the construction material, the process of the construction, to the end user unalterably affect the environment. According to Ojo, Mbohwa, and Akinlabi (2014) construction sector consumes massive portions of natural resources, uses high amount of energy, causes emission and pollution, and generates significant waste. The adverse impacts to the environmental of the construction industry have been well reported. For instance, based on United Nations Environment Program (2013) construction industry is one of significant contributors of emissions to environment which account for around 30-40%. Moreover, according to National Construction Services Development Board of Indonesia [NCSDB] (2013), Indonesia's construction activities have sucked up 40% of the raw materials of natural resources, consumed 36% of the total energy, spent 62.5% of the power supply, absorbs 12% of the water supply, and produced 136 million tons of construction and demolition waste (CDW) annually. Besides, a construction project has several separate phases of process (design, procurement, construction, and operation and maintenance of the final product) and involves many parties in the process. Thus, construction industry is characterized by fragmentation, poor coordination among players and less integrated between processes within the complex supply chain network in project. These have been acknowledged as the major causes of the inferior performance (Abduh & Raharjo, 2013) since the performance of the construction depends on the performance of its supply chain (Glavinich, 2008). However, the nature of today's global business condition forces all the business operation to be competitive not only in the market but also should meet the environmental requirement.

Based on the aforesaid, basically, green supply chain management adoption is the main solution that potentially tackle both issues, the environmental/sustainability issues that face by organization while controlling the effective supply chain (Rao & Holt, 2005; Zhu, Sarkis, & Lai, 2008; Shi & Koh, 2012). GSCM able to tackle the negative environmental impacts of business operation in the entire supply chain (Srivastava, 2007; Zhu, Sarkis, & Lai, 2008). Basically, IT infrastructures and its component facilitate the very basic activities in business operation, which is technical administration, construction related document, employee telecommunicating, and collaboration among all parties involved in a construction project. The entire business operation including the supply chain activities cannot be separated from the use of IT/S. Moreover, as a tool and solver, IT/S holds crucial role in improving upstream, within, and downstream of SCM in an organization (Li, Yang, Sun, &

Sohal, 2009). The past studies have been highlighted the role of IT for SCM. For instance, Gonzálvez-Gallego, Molina-Castillo, Soto-Acosta, Varajao, and Trigo (2015) discussed that integrated information technology and systems can lead to improved business performance of companies in a supply chain. IT/S supports SCM by providing integration and coordination of physical and information flow in the entire supply chain, in which leads to the better supply chain performance (Li, Yang, Sun, & Sohal, 2009; Omar, Ramayah, May-Chuin, Sang, & Siron, 2010). Besides, IT/S play a role in improving the reliability of supply chains (Lam and Ip 2012). The adoption of IT/S can enhance the effectiveness and efficient of material sourcing, material delivery, material storage and handling, and waste management (reverse logistics).

At the same time, the increasing use of IT/S in the entire business operation has indubitably contributed to environmental problem by consuming a plenty energy, generating footprint emission, and disposing a large amount of e-waste. However, the existing studies are lacking in examining the impacts of IT/S on the environment. In contrary to its perilous effect, IT/S is offering promising potential to reverse its negative impact to environment by going green and by using IT/S its self to greening the supply chain activities. These are termed as Green IT/S. Yet, the existing studies are still limited that assess the role of IT/S adoption in helping the organization's actions to meet the ecological sustainability goals in the whole supply chain process. Moreover, the elucidation and practicality of green IT/S its self are still unclear. There are relatively handful research materials available on green IT/S, especially within GSCM in Indonesia construction industry. These leads to the number of queries on green IT/S. When green IT/S starts to emerge? What are the difference between green IT and IT for green (green IS)? How the practicality of green IT/S within GSCM in construction industry? Does green IT/S support the implementation GSCM in achieve supply chain sustainability performance? Hence, this paper seeks to address the lack of a clear view of the state of research at the intersection of green IT/S and GSCM by combining it and aims to deliver an updated perspective of how green IT/S can be used to support the green supply chain management in reaching the sustainable construction.
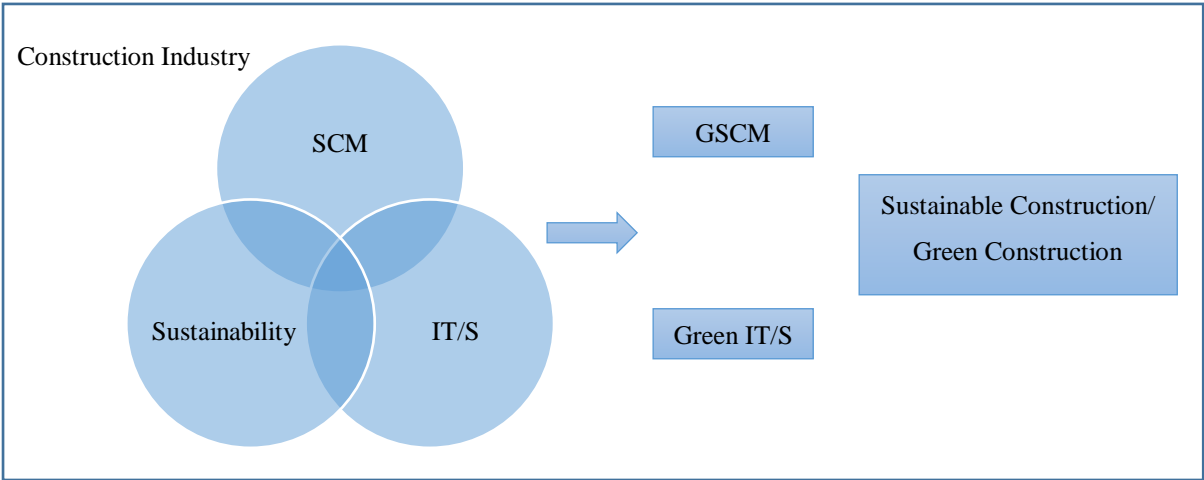

Figure 1: Overlap area of SCM, IT/S, and sustainability including related area being studied

Elucidation

Basically, Green IT/S is a new phase of technological innovation and a set of organizational practices that greening IT/S infrastructure and use IT itself to greening other

domains such supply chain (Mulvaney, 2011). Green IT/S is beneficial not only to the economy aspect by reduce energy consumption while saving costs, but also to the natural environment of our earth by minimizing the negative environmental impact such waste, footprint, and emission and then indirectly to the society by provide the better earth for living.

Green IT/S has appeared principally since 2007 and impressively growth since then as a new business and technological and social phenomenon. The emergence of green IT/S depicts the burden of IT/S on environment. In spite of the fact that IT/S helped expedite the expansion of world trade and industrialization, it has increased the chance of circulation of waste and contamination on environment of our earth. In other words, green IT/S was arisen when the negative environmental impacts of significant IT growth and the increased urgency of dealing with environmental degradation were recognized. According to Siegler and Gaughan (2008) IT/S usage is bursting up, growing two times faster than the Gross World Product. In point of fact, IT growth rates have been immense in the past few years and so have the negatives impact such as natural resource depletion, increasing energy consumption, emission of greenhouse gases, and e-waste. The unsustainable development of such high-tech, high-speed, and intelligent IT/S spent no less amount of fossil fuel, chemical material, and other resources in their manufacture. Two-thirds of computers and their components end up in landfills, damaging natural environment and generating health risk to public society. While increasing natural resources consumption and produce e-waste, the fast growth of unsustainable IT/S also leads to increasing energy demands. The wide application of IT/S in entire business operation activities has forced business to consume large amount of energy. The aforementioned critical events triggered to the movement of green IT/S. The role of IT/S as a solution to rather than a destroyer of environmental sustainability is began to acknowledge and accentuate. The emergence of Green IT has begun to combat the negative environmental of IT/S itself which then evolved to enable environmental sustainability initiatives (Erek et al., 2009; Mulvaney, 2011; Jenkin, Webster, & McShane, 2011). The Climate Group (2008) stated that IT/S can have positive impacts which potentially reduce 15 percent of global emission.

Table 1: A Brief Elucidation of Green IT and Green IS (IT for Green)

Green IT	Green IS (IT for Green)
First order	Second order
Direct impact	Indirect impact
Hardware (IT devices)	Software (applications, systems)
Wise-used of IT (use IT in greener way)	Use IT to greener other activities

The added term of "Green" in "Green IT/S", can be viewed and interpreted from different angles. The limited previous relevant literatures show that green IT/S have been discussed in different dimensions and there is no standard definition of green IT/S. As known, there is also many other terms or names that intended to green IT/S, for instance sustainable IT, green computing, greener IT, and green ICT. But still these various names have the same goals of cost savings, energy efficiency, and carbon footprint reduction for sustainability. Based on the broad definition from several researchers, in simple words, green IT/IS can be defined as information technology and system initiatives/strategies that address environmental sustainability (Boudreau, Watson, & Chen, 2008; Elliot & Binney, 2008; Siegler & Gaughan, 2008; Molla, Cooper, Deng, & Lukaitis, 2009). This means green IT/S is referred to both IT (hardware) and non-IT/by using IT (IS, software) and practices to solve related sustainability problem. The complex relationship between IT and environmental management is caused by IT can have two order effects to the environment. The effects of IT/S on the environment are

explained into first-order or direct effect and second-order or indirect effect. The first-order effect is termed as "Green IT" and second-order effect is termed as "Green IS or IT for Green". Even though the relationship between green IT and green IS are interconnected, they have different focus and purpose (Molla & Abareshi, 2011). The further discussions of green IT and green IS (IT for green) are as follows.

Green IT

The first-order or direct effect refers to the direct negative environmental impact of IT infrastructure and its component itself from the production, design, operation/usage, and disposal. The direct effects involve all form of emissions deriving from the entire value chain of the IT products, from cradle to grave. The emissions derived from IT thus include greenhouse gases and waste of the IT in its end-of-life. Hence, in short, making IT design, production, operation/usage, and disposal greener or more environmentally-friendly refer to "Green IT" (Murugesan, 2008).

Green IT is conceptualized in certain ways rely on its context. Based on Murugesan (2008) green IT is defined as a study and practices of designing, producing, operating/using, and disposing of IT infrastructures including computers, servers and its associated subsystems with minimal or no impact on the environment, energy efficiency and total cost of ownership. Meanwhile, Elliot and Binney (2008) explained Green IT in term of design, production, operation, and disposal of IT and no-IT-enabled product/services, which is not deleterious and beneficial to the environment during its entire life cycle. From the relevant previous literatures, basically, green IT focuses on how to make the technology/IT itself greener.

In today's global business, the use of IT in effectively controlling today's complex supply chain is such a compulsory. IT is not an actual source of competitiveness but a source of competitive necessity (Li, Yang, Sun, & Sohal, 2009). Therefore, the IT is playing a vital role and its usage level is increasing eventually. To begin with, the producing of the IT and its components spends huge amount of resources, hazardous material, and electrical power. The increase use of IT makes the increase of energy consumption and generates more greenhouse gases emission. Most of those IT and its components end up in landfill and pollute the earth. Both IT manufacturer and company who using IT need to implement such green IT in managing its IT. Green IT holds a pivotal role as the solution of environmental sustainability and leads to reach the overall sustainability.

Green IS (IT for Green)

The second-order or indirect effect refers to the positive environmental impacts of using IT on business and economic process to support initiatives in reducing negative environmental impacts. Hence using the IT to make organizations greener refer to IT for Green or also known as Green IS since the IT that used in this term refers to information system or IS (Chen, Boudreau, & Watson, 2008).

Whereas green IT mainly focuses on greening the technology/devices, green IS is using the IT in a form of software or application by involving the people, process, and technologies to support in achieving sustainability goals. Green IS concept can be simply defined as the usage of IS to enable sustainable development in economy (Boudreau, Chen, & Huber, 2007; Watson et al., 2008). Meanwhile, Brooks, Wang, and Sarker (2012) defined

Green IS as the use of IS application in the entire business operation process, from procurement, logistics, disposal, communication between upstream and downstream of supply chain members. Moreover, Green IS having another function which is supporting the better sustainability performance of organizations (Baggia et al., 2016). For instance, use collaborative group software and telepresence to allow communicating and meeting in two or more location simultaneously and to reduce the negative impacts on environment that associated with travel; use environmental information system to track, measure, and monitor the environmental variables which is emission, waste, toxicity, and carbon footprint; adopt information system to reduce overall emission, waste, and hazardous material that may generated by the company; and use IS to transform business operation of the company become more paperless such as e-paper (Watson, Boudreau, Chen, & Huber, 2008). Moreover, Green IS adoption has become the crucial key that supports environmental action such GSCM of company. For example, the use of IS to enhance the environmentally friendly of upstream and downstream supply chain, i.e. in supporting green procurement and green logistics.

It can be concluded that Green IT and Green IS or known as Green IT/S has potential in influencing and strengthening GSCM implementation and resulting the more sustainable outcome of supply chain sustainability performance among contractors in Indonesia construction industry.

Practice

Construction industry has been considered as a late adopter of IT growth in a global context. However, IT utilization and construction industry have significant relationship. IT utilization in construction industry support any type of construction activities, generally transfer the information much faster. For instance, computer, printer, video conference tools, and data centre are the example of IT infrastructure and components that greatly related to construction industry over its business process. Moreover, IT utilization is broadly known as a fundamental for successful supply chain management and a key approach in improving supply chain performance (Craighead & Laforge, 2003; Zhang, van Donk, & van der Vaart, 2011). Hence, it is no exception for construction industry which also utilize IT in supporting its effective supply chain management. The development of IT in construction industry can significantly change company' structures, processes, and relationship with partners. This scenario shows the elevated level of IT usage in construction industry. However, numerous companies lack awareness of their IT impact on environment, standard to measure all emission of their IT, and common understanding of how IT its self can be a solution to environment issues (Mulvaney, 2011). However, green IT is considered as one of the key roles that transform supply chain management function in organization, mainly in construction industry. Furthermore, substitute the traditional technologies with IT will minimize the amount of resources used in the whole business operation of construction industry. It can be concluded that Green IT has potential in supporting the green supply chain management implementation and achieving the better sustainability performance of supply chain within contractors in Indonesia. Hence, such companies in construction industry require investments in green IT to fully utilize the IT applications.

In practice, ideally, green IT/S should address the three pillars of sustainability which is the triple bottom lines that include economic or financial (profit), environmental or ecological (planet), and social (people). Nevertheless, in facts, business organizations are implementing green IT/S practices with the main goals of saving energy to cut off the costs in other words for economic/financial goal, while the environmental and social responsibility are

often marginalized as secondary goals. Basically, for business organizations in engaging green IT/S toward its ideal achievement, the green IT/S should be implemented based on the three interconnected strategies of natural-resource-based view of the firm (NRBV) by Hart (1995). These strategies are pollution prevention, product stewardship, and sustainable development.

Pollution prevention attempts to prevent emission and waste during early stages rather than cleaning them up at the end, in which aims to generate significant savings, fructifying in cost and productivity in other words to achieve economic advantage. Product stewardship extends the pollution prevention scope by mitigating the environmental footprint of activities at each stage of the entire value chain or life cycle of the product, in which to reduce overall environmental cost, to meet system transformation to zero waste, and in associated with gaining legitimacy and reputation in green market condition in other words to achieve environmental responsibility. Finally, sustainable development strategy has notable differences from the other two strategies which is not merely attempt to do less environmental damage but, rather, to actually produce in a way that can be maintained indefinitely into future (i.e. via clean technology, innovation) for the good of organization, human, and earth; and not restricted to environmental concerns of organizational economic activities but also involves focusing on social concern in alleviating poverty for the poorest of world's citizens by creating a new economic activity for society/community.

Practically, the utilization of Green IT/S in organizations aims to achieve the sustainability of our earth by converse the natural environment. Green IT practice in pollution prevention strategy is organizational action in reducing energy consumed by IT infrastructures while Green IS practice is organizational adoption of IS to reduce overall emission, footprint, waste, and toxic materials. For instance, by purchasing eco-friendly IT infrastructures, by designing the IT infrastructure with energy efficiency characteristic i.e. use thin client and virtualization, and by encouraging to operate the IT infrastructure in green manner which means in a way to converse energy. Secondly, the practice of Green IT in product stewardship is organizational action of dispose IT infrastructure in environmentally friendly way while the practice of Green IS is organizational adoption of IS to greener the upstream and downstream supply chain management. Lastly, Green IT practice in sustainable development strategy refers to organizational action on using renewable energy to operate IT infrastructures and Green IS refers to organizational adoption of IS to transform business operation. The detail practice of Green IT and Green IT are shown on the Table 2.

Table 2: The Practice of Green IT and Green IS (IT for Green)

	Green IT	Green IS (IT for Green)
Pollution Prevention	• Have policies to purchase IT infrastructure by considering environmental criteria. • Have policies to use virtualization, thin client, cloud computing, etc. to reduce the number of IT infrastructures used and energy consumed by IT infrastructures. • Have policies to implement PC management. • Have policies to encourage the operation of IT infrastructure in environmentally friendly manner (save energy)	• Encourage the use of software to assess and monitor environmental indicator (emission, footprint, and waste). • Encourage the use of software to reduce overall emission, waste, toxic material consumption.
Product Stewardship	• Have policies to purchase IT infrastructure based on vendor's end-of-life program	• Encourage the use of software to plan and design green supply chain strategy.

	• Have policies to reuse and recycle IT infrastructures and its components to extent its cycle life. • Have policies to dispose IT infrastructures and its components in environmentally friendly manner. • Have policies to participate in product take-back program by suppliers.	• Encourage the use of software to support procurement, supplies delivery, supplies storage and handling, reverse logistics, supplier development activities be more environmentally friendly.
Sustainable Development	• Have policies to use renewable energy to support the operation of IT infrastructures.	• Encourage the use of application for paperless business process. • Encourage the use of application for communication tools beyond email. • Encourage the use of application for collaboration or groupware. • Encourage the use of application for video-teleconference tools.

Source. Adapted from Chen, Watson, Boudreau, and Karahanna (2011)

Conclusion

This study has been shown that Green IT/S has started becoming an essential element in green supply chain management (GSCM) to meet the sustainability goals. Even green IT/S can be said still in early stage of development and adoption but it has potential and play pivotal role in addressing environmental issues, especially by supporting the implementation of GSCM practices. Green IT/S research has been focused on energy efficiency while other have been neglected in the literature. The existing green IT/S literature are still limited on the evaluation of the potential role of green IT/S practices in strengthening the implementation of GSCM practices that might also improve the sustainability performance of supply chain in construction industry context. Thus, this study provides a valuable knowledge for researchers and practitioners to enhance their understanding on green IT/S in GSCM. It would be a fundamental for future research in further exploring on this topic. The research on green IT/S area should be encouraged. Suggestion for future research is the empirical study may be established to increase the understanding about the role of green IT/S in the relationship between GSCM practices and sustainability performance of supply chain. Since the previous studies is mainly focused on environmental aspect of sustainability, the future research is suggested to study on the three aspect of sustainability which is economic, environmental, and social.

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