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ARTICLE (PEER REVIEWED)

Eco-innovation Adoption in Malaysian Contractor Firms: Understanding the Components and Drivers

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Abstract

Eco-innovation (EI) is a concept that integrates eco-consciousness within innovation development. While EI has been widely applied in the manufacturing industry, its adoption in the construction sector remains uncertain. The rising concern of environmental impacts on construction necessitates the importance of finding more innovative ways to push environmental needs within the complexity of projects' design and methods. Contractors hold a strategic position to promote and adopt EI into management, construction, and development. This paper explores 1) the adoption level of EI practices and 2) the relationship between the adoption of EI practices and the factors that drive EI, within the Malaysian contractor firms. A questionnaire survey was developed using 18 EI components and four driving factors. A total of 95 Grade G7 contractor firms responded to the survey. The survey revealed that the level of EI adoption in contractor firms is still at a moderate pace. The results showed that organisational EI is a crucial component that supports the firm's eco-innovative management approach to improve firm's environmental performance. The results indicated that all four driving factors have a positive relationship with the implementation of EI. Technology factor was identified as crucial in influencing better adoption of EI in contractor firms. Findings from this study are beneficial to develop

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a framework on strategies to increase the EI adoption rate among the contractor firms and deepen the understanding of EI implementation at the firm level, further extending to the project site level.

Keywords

Eco-Innovation; Contractor Firms; Driving Factors; Construction; Malaysia

Introduction

Innovation in firms is generally regarded as the basis of business change, growth and effectiveness. It is the key to achieve a competitive advantage and ensuring business survival in a turbulent environment (Doran and Ryan, 2012). In the early 1960s, the connection between innovation and environmental sustainability attracted considerable academic interest. Increasing environmental pressure and support for modernisation means that innovation has become one of the primary means for firms to achieve sustainable development (Cai and Li, 2018). Merging environmental sustainability and innovative concepts would encourage innovation-led actions that prioritise environmental needs and promote new changes and improvements in construction and building projects (Hazarika and Zhang, 2019). The outcomes of such innovation are termed eco-innovation (EI).

EI is usually used interchangeably with environmental innovation, green innovation and sustainable innovation by researchers (Schiederig, Tietze and Herstatt, 2011; Bossle, et al., 2016; Xavier, et al., 2017). According to Pacheco, et al. (2017) and He, et al. (2018), EI is the best term to represent innovation directed towards environmental and economic fulfilment between these four common terminologies. EI creates and develops new business opportunities and benefits by preventing or reducing negative impacts or optimising the use of natural resources (Hazarika and Zhang, 2019). EI has become an inevitable choice for firms as it is a key to green transformation, increasing their competitive advantages and enhancing their environmental performance (Cai and Zhou, 2014; Horbach, Rammer and Rennings,2012; Cai and Li, 2018; He, et al., 2018). Sustainable construction frequently emphasises energy efficiency and effective management of waste and carbon emissions, which are useful approaches but somewhat restrictive (Hazarika and Zhang, 2019). Solely confirming the innovative efforts by focusing on producing energy more efficiently, neglects the possibility of systematically reducing energy demand and minimising waste and carbon emissions over time through innovations (EIO, 2011). Thus, EI in the construction industry aims at finding new or better ways to attain higher functionality with lesser resources, new technological designs, and overall systematic changes in construction processes and management (Reid and Miedzinski, 2008; Hazarika and Zhang, 2019). Hence, understanding EI components relevant to contractors at the firm level would ensure that a firm's management takes the right actions to spur EI and achieve environmental performance in delivering their services.

Two distinct forms of innovation exist in construction: technological innovation and management innovation (Qi, et al., 2010; Lim and Peltner, 2011; Rennings, 2000). The former is associated with adopting technologies in products, services, and processes to improve environmental performance. In contrast, management innovation involves changes in a firm's internal structure, such as the use of Environmental Management System (EMS) (Cheng, Yang and Sheu, 2014), partnering and supply chains (Fernando and Wah, 2017; Ozorhon and Oral, 2017), improved human resources development (Cainelli, De Marchi and Grandinetti, 2015), and new policies, procedures and organisational approaches (Bamgbade, Kamaruddeen and Nawi, 2017) that stimulate the importance of environmental considerations. EI adoption utilises technology and management to produce new products and processes that positively impact the environment (Lim and Peltner, 2011). In this study, the EI practices are classified into three main components: process EI, product EI and organisational EI (Hazarika and Zhang, 2019; Cheng, Yang and Sheu, 2014; He, et al., 2018). EI is embedded in firms' business strategy, and changes may occur in the product, process, and organisational structure of the firm that resulted in significantly lower environmental burdens but concurrent improvements in economic performance (García-granero, Piedra-mu and Galdeano-Gomez, 2018; Arranz, et al., 2020).

Dealing with project complexity becomes more difficult without new or more efficient technology, process, procedure and method, thus sparking innovation. Low levels of innovation within the construction industry have been acknowledged and might threaten the industry's long-term sustainability (Gambatese and Hallowell, 2011). The eco-innovative process has been suggested as the way forward to merge innovation and environmental sustainability (Sanni, 2017; Reid and Miedzinski, 2008. The Malaysian government and non-governmental organisations have initiated various actions to raise awareness of green practices; however, the involvement of contractor firms in adopting green and eco-innovative practices within their business operations and projects remains insufficient (Bamgbade, Kamaruddeen and Nawi, 2017; Bohari, et al., 2015). In addition, the focus on construction innovation and eco-movement concerns have the opposite effect, whereby the environmental impact is often neglected (Xue et al., 2014; Zhiwei, Chen and San, 2014).

Thus, under the Construction Industry Transformation Programmes (CITP) (2016-2020), the Malaysian government is committed to realising various initiatives in CITP Thrust 2: to drive innovation in sustainable construction, to reduce irresponsible waste during the construction process, to facilitate the industry with the adoption of sustainable practices and to force compliance to environmental sustainability ratings and requirements (CIDB Malaysia, 2015). However, most contractor firms continued to interpret applying eco-innovative practices in construction operations as unattractive and likely to be an additional burden (Qi, et al., 2010; Cheng, Yang and Sheu, 2014). The manufacturing industry dominated most EI research in the Malaysian context (Singh, 2017; Salim, Rahman and Wahab, 2018; Fernando and Wah, 2017), with fewer studies focusing on the construction industry. A study by Munodawafa and Johl (2019) revealed that out of 125 reviewed publications on environmental-innovation-related studies and performance literature, 92% were derived from the manufacturing sector. However, as work tasks in the manufacturing and construction industries differ, EI components in the manufacturing industry may be deemed unsuitable for application in construction contexts. Hojnik, Ruzzier and Manolova (2018) suggested that different industries have different components due to the varying work activities and business outputs.

Client needs and requirements can drive change across the construction supply chain; however, the demand for green design, green buildings and eco-products by clients and end-users are still unsatisfactory (Hamid, et al., 2012; Chua and Oh, 2011; Bohari, et al., 2015). Abidin (2010) stated that widespread awareness and agreement on green approaches does not indicate extensive implementation in the industry. Thus, more effective improvements in environmental performance could be achieved if measures or actions were taken on contractors' initiative (Qi, et al., 2010). Hence, contractor firms play an essential role in integrating innovation and environmental practices in their business strategy to achieve tremendous respect for the environment. Although various project stakeholders are involved in delivering a development project (Ozorhon and Oral, 2017), contractors perform the construction work according to the client's designs and specifications and take full responsibility for the completion of the project, according to the contract (Hashim, 2018; Setiawan, Erdogan and Ogunlana, 2017). The contractor acts as the primary interface between the client and consultants and with various organisations i.e., suppliers and sub-contractors. Thus, in this study, contractor firms were selected because they are accountable for delivering the project to the client within the stipulated terms of the contract and have a dominant influence over environmental impacts due to the construction activities (Yusof, Awang and Iranmanesh, 2017). Firms adopting EI engaged in new activities in their processes, products, and organisational systems to improve the efficiency of the construction process, the conservation of natural resources during the process of construction, and reductions in the amount of total waste and emissions produced (Cai and Li, 2018; Hazarika and Zhang, 2019). As a result, firms' original structure will no longer be effective, and they need to adapt to the changes by incorporating eco-innovative concepts in their business routine.

In this context, defining the factors that influence the adoption of EI practices is crucial. Previous studies have investigated EI drivers from a firm-level perspective (Bossle, et al., 2016; Cai and Li, 2018). Several theoretical approaches recognised two EI drivers categories in all firms: external and internal drivers (Horbach, 2008; Horbach, Rammer and Rennings, 2012; Del Rio, Penasco and Romero-Jordan, 2016; Sanni, 2017). Although these works have made essential contributions explaining the influential factors that affect the development of EI in all firms, the ways they have explicitly affected contractor firms have been scarcely discussed or analysed. It is unclear if these factors could encourage contractor firms to adopt EI practices in their business (Fernando, Wah and Shaharudin, 2016; Hazarika and Zhang, 2019). This paper addresses this gap by identifying the EI components and determining the factors that induce eco-innovative practices among Malaysian contractor firms. In developing a contractor's capability to engage in sustainability-oriented approaches in management and services, the interrelationship between the factors that drive EI adoption should be investigated (Hazarika and Zhang, 2019; Bossle, et al., 2016). This study assists contractor firms in enhancing EI adoption to improve current construction services at the firm level, which is also linked to sustainable firm performance.

This paper elaborates on the concept of EI, components of EI and the driving factors for contractor firms to adopt EI in their business practices. The research method adopted was briefly explained prior to explaining the significant findings of the research. The results are divided into two sections: the adoption of EI components in contractor firms and its relationship with the driving factors of EI adoption.

Literature Review

This section comprises three themes: understanding the EI concept, the components of EI adoption and factors that influenced EI adoption by contractor firms in Malaysia.

UNDERSTANDING OF THE CONCEPT OF ECO-INNOVATION (EI)

Kemp and Pearson (2007, p.7) defined EI as "the production, assimilation or exploitation of a product, production process, services, management or business method that is novel to the organisation (developing or adopting it) and which results, throughout its life-cycle lead, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy) as compared to relevant alternatives". This definition provided an apparent reference to a firm as a specific typology of EI. EI provided means to increase efficiency and productivity while minimising the negative impacts on the environment (Doran and Ryan, 2012; Fernando and Wah, 2017). EI involves a broad concept, Rennings (2000, p.322) defined EI as "all actions of relevant actors that develop, apply or introduce new ideas, behaviour, products and processes, which contribute to reducing environmental burdens or ecologically specified sustainability targets". EI has emerged as an essential ingredient in a firm's innovative business strategy by creating value, competitive advantages and increasing the firm's performance without compromising the natural environment (Arranz, et al., 2020; Singh, 2017).

In the context of this study, EI is defined as innovation that is introduced to firms or projects in the form of new or improved versions of products, services or processes, or organisational management practices which produces better or more efficient services and contributes to environmental improvement. The positive environmental impact of innovation is the core element of this definition as EI results in economic and environmental benefits. EI adoption has contributed to both economic and environmental benefits in delivering quality building and infrastructure. In that case, if the contractors do not adopt EI within the firm, their ability to leverage EI at the project level would not be realised (Hazarika and Zhang, 2019). Thus, from the micro-level perspective, the eco-movement within the construction industry can be efficiently expedited by contractors when EI adoption begins within their firm level. Accordingly, EI components are categorised into process EI (productive efficiency), product EI (product quality) and organisational EI (organisational effectiveness); these terms are explained further.

COMPONENTS OF ECO-INNOVATION (EI) ADOPTION IN CONTRACTOR FIRMS

EI practices have the potential to support sustainable growth and the long-term viability of contractor firms. To remain competitive and relevant, contractors must change their business routines to become more eco-innovative. Therefore, identifying EI components can help contractors adopt EI practices effectively and achieve sustainable competitive advantages.

PROCESS EI (PRODUCTIVE EFFICIENCY)

Cheng, Yang and Sheu (2014) claimed that process EI concerns with implementing new or significantly improved production processes or delivery methods, which reduce environmental impacts. The objectives of process EI are to reduce the duration and cost of operations, stimulate energy efficiency, conserve natural resources, improve the quality of the end-product, and reduce the release of hazardous waste and pollution to the environment (Lee and Min, 2015; Hazarika and Zhang, 2019). In this paper, process EI refers to improving existing construction processes or developing new techniques or technology that (fully or partially) change the way buildings are being constructed with minimum adverse impacts on the environment. The main component of process EI is related to green technologies and green operations. Green technology is essential in achieving specific EI outcomes (Horbach, Rammer and Rennings, 2012). The arrival of a new round of technological innovation is a challenge and an opportunity for green development to improve natural resources utilisation effectively (Miao, et al., 2017). Thus, contractor firms must always be aware of new technologies to enhance their construction practices and positively impact the environment to achieve significant operational improvements (Hashim, 2018). Reviews by Horbach, Rammer and Rennings (2012) and Lee and Min (2015) found that EI practices are positively related to firm-level investment commitments in research and development (R&D). Establishing an in-house R&D unit or department can be crucial to devising eco-innovative solutions and promoting enhancement and efficiency in services rendered (Lee and Min, 2015). Accordingly, Hamid, et al. (2012) and Ozorhon and Oral (2017) specified that contractor firms need to embrace the adoption of modern methods of construction, and features like the Industrial Building System (IBS), Building Information Modelling (BIM) and Smart Integrated Technology, to enhance the management of the construction process and simultaneously be able to protect and conserve land, water, energy and other finite resources. Eco-innovative approach should include improving the guidelines and procedures that are adhered to at the firm and project level (Hazarika and Zhang, 2019; Bamgbade, Kamaruddeen and Nawi, 2017). Contractor firms must remain committed to implementing environmental pollution plans to avoid losses or delays that might affect the construction process's smoothness in complying with environmental regulations (Bamgbade, Kamaruddeen and Nawi, 2017). Thus, contractor firms need to be well-resourced to meet the increasing demands of clients and consultants in delivering their services effectively and fulfil environmental sustainability goals.

PRODUCT EI (PRODUCT QUALITY)

Product EI refers to adopting new products or services with significantly improved environmental and performance characteristics in delivering sustainable building and infrastructure. In this study, product EI is defined as the application and adoption of new or significantly improved products (regarding their characteristics), technical components and materials that reduces environmental impacts throughout their life cycle (Carrillo-Hermosilla, Del Río and Könnölä, 2010; Cheng and Shiu, 2012). The environmental impact of product EI stemmed from the usage of items throughout the building life-cycle and their disposal rather than the manufacture. Thus, the main components of product EI are the management of the product and the adoption and procurement of eco-products undertaken by contractors. Clients' demands for new products and the firm's managerial aims to penetrate new markets form part of the rationale behind product EI (Bamgbade, Kamaruddeen and Nawi, 2017). Contractors can recommend to clients and consultants eco-innovative products and materials that will increase product durability, quality and energy efficiency, reduced replacement rates and lower carbon emission throughout the building's life span (Qi, et al., 2010; Cheng and Shiu, 2012). This underlines the importance of contractor firms to be equipped with up-to-date knowledge on eco-innovative products and materials. Supplying clients and end-users with eco-innovative construction products and materials assists in achieving environmental sustainability and provides a better quality of life for end-users (Fernando, Jabbour and Wah, 2019). Contractor firms can gain competitive advantages by becoming early adopters of eco-innovative construction products and materials (Bamgbade, Kamaruddeen and Nawi, 2017). A firm's ability to innovate early in construction products is key to adapting to customers' changing needs and enhancing the functionality of construction components, which includes using fewer materials and less energy during material transportation and on-site installation processes (Zhiwei, Chen and San, 2014). Thus, maintaining good relationships with local product and materials suppliers based on project location could reduce pollutions caused by transportation while saving time and cost. Proper arrangements and guidelines for product and materials storage can minimise pollutions and unexpected waste on-site (Gambatese and Hallowell, 2011). The practice of green procurement in purchasing products and services can also minimise environmental consequences (Peng and Liu, 2016). Currently, some suppliers are actively developing construction products from recycled, re-used and renewable (3R) materials (Bohari, et al., 2015). Contractor firms could develop a plan to promote 3R strategies in selecting products and materials for clients and consultants. According to Peng and Liu (2016) and García-granero, Piedra-mu and Galdeano-Gomez (2018), eco-products are less resource-intensive, more energy-efficient and more easily recyclable over the whole building life cycle. Buildings that utilise green materials and eco-products contribute significantly to environmental sustainability. By venturing into new eco-product and materials, a contractor firm obtain more significant opportunities to grow and establish its dominant competitive position while gaining substantial leverage within the industry.

ORGANISATIONAL EI (ORGANISATIONAL EFFECTIVENESS)

Organisational EI introduced a novel approach to a firm's business management practices in dealing with environmental issues in the context of process and product innovation (Kemp and Pearson, 2007). In this study, organisational EI involves in facilitating and re-organising firms' routines, procedures, structures, policies, managements, or systems to deal with environmental requirements (Bamgbade, Kamaruddeen and Nawi, 2017). Several researchers (Triguero, Moreno-Mondéjar and Davia, 2013; Cheng, Yang and Sheu, 2014; Kesidou and Demirel, 2012) have identified how organisational EI positively facilitated the implementation of product EI and process EI in firms. They highlighted that firms' decisions to adopt organisational EI mainly focus on adherence to environmental regulations and standards, including non-mandatory measures such as green rating tools. Apart from that, improving the firm's human resources and developing good relationships and collaborations in the supply chain are also an example of an organisational EI. Adopting an EMS by a contractor firm as part of their environmental strategy had signal other stakeholders that a firm's commitment is being made to demonstrate environmental management. Cai and Li (2018) and Hojnik and Ruzzier (2016) stated that EMS could identify where upgrades and other environmental improvements best fit into an overall business strategy and helps firms evaluate the costs and benefits of making changes, leading to well-informed decisions. For EI adoption to succeed, a contractor firm must continue providing education and training to up-skill the employees' environmental knowledge and motivate them with remuneration and promotion based on environmental initiatives. Knowledgeable employees are needed to develop, manage, and control eco-innovative measures in contractor firms (Fernando, Jabbour and Wah, 2019). Generally, EI activities require more significant external sources of knowledge and technology than general innovation (Horbach, Rammer and Rennings, 2012; Cainelli, De Marchi and Grandinetti, 2015). Singh (2017) and Tariq, et al. (2017) highlighted that environmental knowledge embodied in green technology and R&D is usually obtained from external sources. Thus, collaboration and networking with external vendors on knowledge sharing enable full awareness of the latest green technology, knowledge, and eco-products, which positively influences firm-level EI activities (Tariq, et al., 2017; He, et al., 2018). Hence, the study of the literature has identified 18 sub-components of EI adoption, consisting of process EI (6-items), product EI (7-items) and organisational EI (5-items). These sub-components are listed in Table 1 below.

FACTORS THAT INFLUENCED ECO-INNOVATION (EI) ADOPTION AMONG CONTRACTOR FIRMS

This section reviews the literature on the factors that influenced EI adoption and develops the research hypotheses. EI is driven by both internal and external forces (Salim, Rahman and Wahab, 2018; Cai and Zhou, 2014; Bossle, et al., 2016). The internal drivers consist of technology and firm-specific factors, while the external drivers include environmental and market factors (Hojnik and Ruzzier, 2016; Cai and Zhou, 2014). Understanding all these crucial drivers on the adoption of EI from the contractors' perspective could facilitate the development of strategies to enhance the execution of eco-innovative practices in their firms.

FIRM-SPECIFIC FACTORS

Firm-specific factors refer to a firm's ability to improve its resources, capabilities and knowledge to implement new and advanced EI to attain competitive advantages and achieve better environmental performance. Substantial resources such as technological capabilities, the quality of human resources and the firm's managerial direction are critical drivers for EI adoption. Sanni (2017) recommended that EI is stimulated internally at the firm level since the firm's technological capabilities are crucial determinants of the process EI initiation. Technological capabilities usually enhance environmental and non-environmental process innovations (Triguero, Moreno-Mondéjar and Davia, 2013). For instance, a firm that advances in green technology can reduce waste and pollution and substantially change the construction process. A firm that specialises in EI knowledge can encourage further developments in and adoption of new product EI and process EI (Cai and Li, 2018; Horbach, Rammer and Rennings, 2012). The emerging role of green knowledge has made this a valuable property for firms. Thus, firms are able to leverage and manipulate existing knowledge and search for new relevant knowledge to improve their business and hold an advantage (Arranz, et al., 2020). Furthermore, a firm that practises EI by deploying the latest green technology and sufficient physical assets, such as plants and machinery, can minimise its carbon emissions, reduce its waste and improve its service efficiency (Fernando and Wah, 2017; Gambatese and Hallowell, 2011). The support and commitment of top management are crucial to integrating innovation and sustainability in the firm's environmental strategy, which impacts the firm's ability to eco-innovate (Del Rio, Penasco and Romero-Jordan, 2016; Bossle, et al., 2016; Singh, 2017). A firm's commitment to EI should motivate their employees to practise EI at firm and project levels. Xue, et al. (2014) and Tariq, et al. (2017) stated that qualified and competent employees who can cope with EI technological sophistication and complexity would be driven to excel in environmental endeavours. Employee participation in innovation and training allows firms to rely on their high-quality staff (Bossle, et al., 2016). Firms that allocate sufficient capabilities and resources to EI adoption would achieve better environmental performance and competitiveness.

Hypothesis 1: Firm-specific factors are positively associated with eco-innovation practices.

Table 1. Summary of EI components

EI components		EI sub-components	Sources
Process EI	Green Technology	PE1 - Centralised database for green technology and knowledge as a source of information for multidisciplinary teams in the firm. PE2 - The establishment of R&D unit to develop in-house solutions to promote efficiency in services rendered. PE3 - Deployment of modern methods of construction, IBS, BIM to protect and conserve land, water, energy and other finite resources. PE4 - To be well-equipped with advanced technological plant and machinery, management techniques to overcome complexity in the services rendered.	Qi, et al., 2010; Horbach, Rammer and Rennings, 2012; Lai, et al., 2017; Miao, et al., 2017; Lee and Min, 2015; Hashim, 2018; Bamgbade, Kamaruddeen and Nawi, 2017.
	Green Operations	PE5 - Utilise a waste management policy that includes guidelines and procedures that are adhered to at firms and project sites. PE6 - Firm's commitment to continual improvement of the pollution prevention plan to protect the natural environment for the duration of the service.	Gambatese and Hallowell, 2011; Hashim, 2018; Bamgbade, Kamaruddeen and Nawi, 2017.
Product EI	Product management	PRE1 - Provide an up-to-date database of eco-innovative products and materials within the firm to be recommended to clients or consultants. PRE2 - Identify and maintain good relationships with local product and material suppliers for future projects PRE3 - Provide proper arrangements and guidelines for product and materials storage for every project.	Zhiwei, Chen and San, 2014; Bohari, et al., 2015; Cheng, Yang and Sheu, 2014.
	Adoption of product	PRE4 - Early adoption of eco-innovative construction products and materials based on client and consultant needs. PRE5 - Ability to adopt eco-innovative construction products and materials used by other firms.	Bamgbade, Kamaruddeen and Nawi, 2017.

Table 1. continued

EI components		EI sub-components	Sources
	Green procurement	PRE6 - Recommend to clients and consultants eco-products and materials from suppliers listed in the MyHijau Directory and Green Pages Malaysia. PRE7 - Develop a plan to promote to clients and consultants the usage of 3R strategies in the selection of products and materials.	Bohari, et al., 2015; Kesidou and Demiral, 2012; Hojnik and Ruzzier, 2016; Peng and Liu, 2016.
Organisational EI	Firm policy and standard	OE1 - Provide written environmental documentation, such as policies, mission statements, rules or procedures to protect the environment (i.e., EMS). OE2 - Implement regular environmental auditing at firm and project levels to adhere to environmental regulations and standard requirements.	Hashim, 2018; Kemp and Pearson, 2007.
	Supply-chain and collaboration	OE3 - Maintain collaboration and good relationships within the supply chain for knowledge sharing and training to be fully aware of the latest green technology, knowledge of construction processes and eco-products.	Cheng, Yang and Sheu, 2014; Tariq, et al., 2017.
	Human resources	OE4 - Provide education, training and upskilling for the employees on the knowledge of environmental practices. OE5 - Motivate employees with remuneration and promotion based on environmental initiatives and improvements to their service rendered.	Triguero, Moreno-Mondéjar and Davia, 2013.

TECHNOLOGICAL FACTORS

Technological factors are linked in developing technology-driven and technological resources. A firm needs to eco-innovate so it can compete and survive in the construction industry. Lai, et al. (2017) and Chen, Cheng and Dai (2017) suggested that a firm's technological innovation is mainly driven by internal (innovation goal and consciousness) and external (collaboration and incentives) environmental forces. The essential feature of creating such technological drivers is a firm investment in R&D for technological advancement in their operations (Fernando and Wah, 2017; Horbach, Rammer and Rennings, 2012). Cainelli, De Marchi and Grandinetti (2015) and Del Rio, Penasco and Romero-Jordan (2016) stated that having an R&D department is positively correlated with the introduction of EI in a firm. Based on Horbach's (2008) empirical analysis of German firms, the enhancement of technological capabilities (measured in terms of R&D) and employees' competence are critical in firms' favouring EI adoption. In terms of carbon emissions reductions in building construction, contractor firms that demonstrated proactive environmental management practices are committed to developing an internal low-carbon policy in their operations by deploying green technology for energy efficiency as an alternative means in overcoming environmental problems (Gambatese and Hallowell, 2011). To successfully apply green technology, a firm should have competent employees with the appropriate knowledge and skills. The successful implementation of EI should integrate environmental and operational knowledge (Fernando, Jabbour and Wah, 2019). Thus, having qualified and technology-savvy employees contributed to improvements in EI practices.

In adopting EI, the literature highlighted that EI activities require access to external knowledge on advanced technologies, which can be achieved by collaborating with research institutes, making alliances, networking and creating new partnerships (Triguero, Moreno-Mondéjar and Davia, 2013; Cainelli, De Marchi and Grandinetti, 2015). Thus, a firm with effective networking can continuously improve its technological knowledge and capabilities and support EI implementation efficiently (Triguero, Moreno-Mondéjar and Davia, 2013). Chen, Cheng and Dai (2017) revealed that firm investment in R&D and the acquisition of external technologies had influenced and increased regional eco-innovation levels in China. The government's available resources, such as grants and incentives, had encouraged firms to initiate new green technology and become pioneers in applying new technologies or plants and machinery in construction projects (Tsai and Liao, 2017; Bohari, et al., 2015). In summary, these technological factors, including tangible and intangible resources, competent and knowledgeable employees, and collaboration with other firms, had driven contractor firms to adopt EI.

Hypothesis: Technological factors are positively associated with eco-innovation practices.

ENVIRONMENTAL FACTORS

Environmental regulation refers to governmental general rules and policies that aim to control pollution and protect natural resources. Regulation constitutes the most commonly and frequently triggered driver in EI adoption. Empirical evidence from previous studies have shown that the enforcement of environmental regulations is a significant factor in driving and stimulating EI implementation (Horbach, Rammer and Rennings, 2012; Triguero, Moreno-Mondéjar and Davia, 2013; Cai and Zhou, 2014; Kesidou and Demirel, 2012). The well-established Porter hypothesis, cited by other previous studies (Cai and Li, 2018; Bossle, et al., 2016), mentioned that more stringent and properly designed environmental regulations might encourage firms to comply with environmental requirements by implementing a formal environmental management system. Thus, it has been reported that firms implement an EMS, such as ISO14001 certification, to demonstrate their commitment to environmental concerns (Kesidou and Demirel, 2012). Additionally, compliance with environmental regulations can avoid any unnecessary economic penalties for non-compliance.

Moreover, firms that exceed the minimum compliance could enjoy first-mover advantages by pioneering forms of innovation (Cai and Li, 2018). The Malaysian government had implemented various policies and regulations, such as the Environmental Quality Act (1974), the Solid Waste and Public Cleansing Management Act (2007), the National Green Technology Policy (2009), the Green Technology Master Plan 2030 (2013) and the Renewable Energy Act (2011), to conserve the environment and ensure sustainable development for future generations (Jang, et al., 2015; KeTTHA, 2017). Apart from enforcement, government subsidies and incentives could stimulate EI. Horbach, Rammer and Rennings (2012) presented statistical support for the positive and significant influenced of subsidies on eco-innovation. The relevance of subsidies for eco-innovation was also outlined by Del Rio, Penasco and

Romero-Jordan (2016) and Cainelli, De Marchi and Grandinetti (2015). In Malaysia, the government have made extensive efforts to provide subsidies and tax incentives to drive green implementation (Bohari, et al., 2015; Greentech Malaysia, 2016). Long, et al. (2017) also revealed that a firm that consistently adheres to environmental regulations and policies can enhance its reputation and image while improving its economic performance. Governmental pressure using soft and hard approaches has proved to influence firms' intentions to comply; hence, it appears to be a solid antecedent for EI adopters excelling in their services and meeting environmental requirements.

Hypothesis 3: Environmental factors are positively associated with eco-innovation practices.

MARKET FACTORS

Market factors also drive EI implementation in contractor firms since end-users or business customers are now concerned about the environment and demand for environmentally friendly end-products. Consumers' environmental awareness contributes to the market pull demanding sustainable production and consumption (Hazarika and Zhang, 2019). Kesidou and Demiral (2012) claimed that understanding and integrating customer benefits in project development would generate more robust demand for green buildings and eco-products, which, in turn, would motivate contractor firms to engage in EI. Triguero, Moreno-Mondéjar and Davia, (2013) found empirical evidence using a sample of 27 European countries to illustrate that market share and market demand for green products have significant and favourable influence on product EI and organisational EI. Currently, client needs are highly complex and environmentally-oriented towards incorporating innovative practices, green technology and processes in construction projects. According to Triguero, Moreno-Mondéjar and Davia, (2013) and Del Rio, Penasco and Romero-Jordan (2016), the increased green awareness and education is the prime reason for the greater pressure to demand greener construction end-products. The increasing demand for environmentally friendly end-products can be crucial in achieving a better quality of life for end-users (Bossle, et al., 2016). Therefore, contractor firms that comply with accentuated market demand for environmentally friendly end-products that incorporate eco-innovative technology and operations will enhance their EI as part of their services rendered.

Hypothesis 4: Market factors are positively associated with eco-innovation practices.

Research Methodology

This study adopted deductive perspectives to test and confirm the hypotheses. The quantitative research method was used to optimise the understanding, gather factual data and analysed it through statistical procedures to study the relationships between the variables and how they are interrelated (Naoum, 2019; Creswell, 2014). The questionnaire consists of three sections: respondent information, the level of EI adoption and the driving factors that influence EI adoption in contractor firms. The instrument employed to measure the adoption of EI components (i.e., process, product and organisational) was adapted and modified from previous scholars (see Table 1). This study used 7-point semantic differential scale to measure each construct in the survey. The scale utilised ranges from "not implemented" (1) to "strongly implemented" (7), and was used to determine the adoption of EI practices in the sample firms. The driving factors (firm-specific factors, technological factors, environmental and market factors) were also adapted from previous literature reviews (Rennings, 2000; Triguero, Moreno-Mondéjar and Davia, 2013; Tariq, et al., 2017; Ozorhon and Oral, 2017; Bossle, et al., 2016; Horbach, Rammer and Rennings, 2012; Del Río, Penasco and Romero-Jordan, 2016; Fernando and Wah, 2017; Cai and Li, 2018). The survey elicited the extent of the respondents' agreement or disagreement with the statements relating to the main drivers. The answers ranges from "strongly disagree" (1) to "strongly agree" (7). The items measured under firm-specific factors consist of the technological capability of the firm, skilled and competent employees and organisational direction towards EI. Technology-driven and technological resources are the items measured under technological factors. Environmental factors consist of regulatory pressure, government initiatives and company image. Lastly, market factors consist of client demand and customer awareness.

The unit of analysis in this study was the firm. In this study, a contractor firm was defined as a legal entity under contract and entrusted by a client to construct a construction project according to the agreed designs and specifications within a specified time (Hashim, 2018; Setiawan, Erdogan and Ogunlana, 2017). In Malaysia, all contractor firms must be registered under Construction Industry Development Board (CIDB). Currently, there are over 80,000 registered contractor firms with CIDB, ranging from grade G1 to G7. Only grade G7 contractor firms with unlimited tendering capacity were selected to participate in the study. The reason was that grade G7 contractor firms undertake most large-scale development projects because they are licensed to be involved in such projects. EI is not limited to green developments but extends to all construction projects, thus innovation is usually present in any project. In any large project, environmental concerns cannot be neglected (Hazarika and Zhang, 2019). Large-scale construction projects have greater environmental impacts compared to small projects. In addition, grade G7 contractor firms own the resources and capabilities needed to embark on major and complex projects (Bamgbade, Kamaruddeen and Nawi, 2017). Thus, it is highly likely they would have been involved in EI practices at some level because EI practices are unavoidable for G7 firms despite the possibility of the firms not realising it. They are knowledgeable and experienced in progressing a construction project effectively to achieve the time, cost, quality, environmental and safety and health goals.

Thus, the respondents were identified from a list of Grade G7 contractor firms obtained from the CIDB website. There are over 7,000 registered contractor firms' grade G7 under CIDB as of 2019 in Malaysia. Based on the generalised sample size parameters outlined by Krejcie and Morgan (1970), a sample size of 364 was needed in this study to represent a given population. Hence, the random sampling technique was used in this study to indicate that each sample has an equal probability of being chosen. To obtain the targeted sample size, the questionnaire survey was administered using both self-administered and online survey using Google Forms. The researcher obtained assistance from CIDB to enable the distribution of the questionnaire through conferences and workshops organised by CIDB. The researcher also administered the survey face-to-face at the contractor firms' office. The online survey was extensively used in this study because it provided convenience for the respondents while covering a wider geographical area. As recommended by Bamgbade, Kamaruddeen and Nawi (2017), the distribution of the survey could be double the sample size. Thus, 730 questionnaires were sent to contractor firms, and 95 usable responses were received from all sources, indicating a 13% response rate. The response rate is considered low; however, according to Dulaimi, et al. (2002) and Waris, et al. (2014), the construction industry has always been associated with a low response rate.

Reliability refers to the constructs' internal consistency in the traditional sense (Bamgbade, Kamaruddeen and Nawi, 2017). To ensure the reliability of the responses, the survey was distributed to the targeted respondents as firm representatives, who were in top management to middle management positions (Hojnik and Ruzzier, 2016). They were selected as firm representatives because they were directly involved in the process, making them knowledgeable and experienced in all operations and engaged in firm management issues and decision-making (Bamgbade, Kamaruddeen and Nawi, 2017). The collected data was analysed using SPSS version 23. In this study, Cronbach's Coefficient Alpha was used to examine the internal consistency of each factor to gauge its reliability (Pallant, 2016). Table 2 illustrated the Cronbach's Alpha for the 7-constructs used in this study. The values of Cronbach's alpha ranged from .913 to .947; these figures were above the limit of .70, as suggested by Nunnally (1978, cited by Cheng, Yang and Sheu, 2014, p.85). Overall, the Cronbach's Alpha values were above .70 for this study, which was considered acceptable to achieve internal construct consistency. The data collected by the study instrument were valid and reliable. Thus, further analysis could be performed to achieve the study aims.

Table 2. Cronbach's Alpha

Constructs	Cronbach's Alpha	Constructs	Cronbach's Alpha
Independent variables:		*Dependent variables:*	
Firm-specific factors	.935	Process EI	.933
Technological factors	.947	Product EI	.913
Environmental factors	.935	Organisational EI	.932
Market factors	.918		

Research Findings

This section presents the respondents' information, the results from the data analysis and the discussion. This study produced invaluable insights into the progress of eco-innovative construction practices in contractor firms in the Malaysian construction industry.

RESPONDENT PROFILE

The respondent profile encompasses the characteristics of the analysed firms. A total of 95 contractor firms in Malaysia participated in the study. The survey result showed that most firms that participated in the survey were highly experienced in construction. Most firms have been established in the construction industry for 6 to 20 years (53.6%) or over 20 years (39%). Half of the firms (48.4%) had over 50 employees. The majority of the participating firms were ISO 14000:2015 certified companies, contributing to 49.5% of the total sample. The survey observed that 48.4% of the firms have green development project experience. Thus, the contractor firms in the sample were sufficiently mature and demonstrated that they were capable of implementing eco-innovative practices.

THE ADOPTION LEVEL OF EI PRACTICES IN CONTRACTOR FIRMS

The adoption levels of EI components of the 95 Malaysian contractor firms were analysed (see Table 3). Descriptive analysis was undertaken to measure the rate of adoption of EI practices by the contractor firms. The results revealed that product EI and organisational EI contributed slightly higher mean results, with an average mean of 5.10 and 5.12, respectively, compared to process EI (average mean 5.07). The analysis result for process EI, indicated that the contractor firms emphasised on adopting effective guidelines and procedures on waste management adhered to firms and on project sites (highest mean value 5.36). The results found that green technology availability was crucial to ensure the successful adoption of EI during the construction process. Contractor firms had reinforced their position through acquiring advanced technological plant and machinery and management techniques to achieve a better environmental performance when delivering their services and meeting client demands (mean value 5.18). The adoption of new modern construction methods and the continual improvement of pollution prevention plans are crucial at the construction stage when the natural environment needs to be protected (both had a mean value of 5.11). One unanticipated finding was that establishing a R&D unit within the firm was the least significant construct adopted by the contractor firms (mean value 4.66).

In terms of product EI, a contractor firm's ability as an early adopter of eco-innovative construction products and materials was the most significant construct (mean value 5.34). Product management, such as proper guidelines for product and materials storage (mean value 5.27), was adopted to avoid unwanted wastage. Securing good relationships with the local suppliers of products and materials can reduce energy consumption, carbon emissions and the negative environmental impacts of transportation (mean value 5.25).

Table 3. Level of adoption of EI practices by Malaysian contractor firms

Components of EI practices			Mean	Standard deviation	Average mean
Process EI (PE)	Green Technology: Green Operation:	PE1 PE2 PE3 PE4 PE5 PE6	4.97 4.66 5.11 5.18 5.36 5.11	1.106 1.334 1.153 1.052 1.091 1.153	5.07
Product EI (PRE)	Product management: Adoption of product: Green procurement:	PRE1 PRE2 PRE3 PRE4 PRE5 PRE6 PRE7	4.98 5.25 5.27 5.34 5.17 4.84 4.85	1.082 .978 1.125 1.006 1.078 1.114 1.263	5.10
Organisational EI (OE)	Firm policy and standard: Supply chain and collaboration: Human resources:	OE1 OE2 OE3 OE4 OE5	5.02 5.03 5.12 5.25 5.18	1.041 1.026 1.040 1.148 1.203	5.12

Conversely, the adoption of green procurement by contractor firms is considerably low. Recommendations to procure eco-products or green materials, including promoting 3R strategies to clients and consultants, revealed the lowest mean values, of 4.84 and 4.85, respectively.

On the other hand, contractor firms' adoption of organisational EI practices was average, with the mean value ranging from 5.02 to 5.25. These results indicated that the contractor firms were aware of the importance of staff development. Thus, they continuously provided their employees with sufficient education, training, and upskilling their knowledge of environmental concerns (mean value 5.25). Moreover, the contractor firms also motivated their employees with remuneration and promotion for their environmental initiatives, with a mean value of 5.18. Almost identical results were obtained related to the contractor firm having excellent collaboration and networking in the supply chain and their use of external sources for knowledge sharing and training to remain aware of the latest green technology, knowledge and eco-products (mean value 5.12). The implementation of environmental auditing also experienced relatively low adoption in contractor firms, with a mean value of 5.03. Similar results (mean value 5.02) illustrated that having written environmental documentation, such as company policies, standards or procedures, was a matter of less concern.

THE RELATIONSHIP BETWEEN THE ADOPTION OF EI PRACTICES AND ITS DRIVING FACTORS

This study extended the analysis to determine the relationship between factors influencing the contractor firms to adopt EI practices. This section presents the results of the hypotheses stated earlier. The Pearson correlation coefficient was employed to determine the relationship between the adoption of EI practices and the factors that drive EI, within the Malaysian contractor firms. Preliminary analyses were performed to prevent any violation of the assumptions of normality, linearity, and homoscedasticity (Pallant, 2016). The results are shown in Table 4; the mean, standard deviation and correlation matrix for all investigated variables are presented in the study. The data shows that multicollinearity was unlikely to be a problem (Pallant, 2016).

The Pearson correlation coefficient matrix indicates R-values that show the strength of the relationship between these variables (Pallant, 2016). Cohen (1988, cited in Pallant, 2016, p.137) suggested the following guidelines for interpreting R-values: low if R-value = .10 to .29; moderate if R-value = .30 to .49; and strong if R-value = .50 to 1.00. The results obtained in Table 4 displayed a statistically significant positive relationship between EI adoption and the factors influencing the EI practices by contractor firms, with P-values greater than the significant value of 0.01. The results indicated a moderate to a strong positive relationship between firm-specific factors, technological factors, environmental factors, and market factors associated with the adoption of EI practices in process, product and organisational by the contractor firms, which means all the hypotheses are supported.

Table 4. Pearson Correlation Coefficient matrix of EI practices and driving factors

Variables	Mean	SD	1	2	3	4	5	6	7
1. Firm-specific	5.17	.935	1						
2. Technological	5.33	1.031	.807**	1					
3. Environmental	5.47	.940	.755**	.742**	1				
4. Market	5.19	1.075	.608**	.671**	.591**	1			
5. Process EI	5.06	.997	.587**	.637**	.548**	.539**	1		
6. Product EI	5.10	.888	.617**	.696**	.578**	.626**	.842**	1	
7. Organisational EI	5.12	.970	.607**	.651**	.625**	.641**	.785**	.881**	1

n=95, **correlation is sig. at $p < 0.01$ (2-tailed)

Discussion

The empirical results from this study demonstrated the adoption of three EI components - process EI, product EI, and organisational EI, emphasising contractor firms that operate in the Malaysian construction industry. The outcomes of this study revealed the level of EI adoption by contractor firms and the motivational factors that drive them to improve these practices for environmental goals and competitive advantages to be achieved.

THE ADOPTION LEVEL OF EI PRACTICES IN CONTRACTOR FIRMS

The findings indicated that the adoption level of EI practices among grade G7 contractor firms remains moderate. Among the three components observed, organisational had more impact on a firm's EI implementation than process and product. Although a previous study by Bamgbade, Kamaruddeen and Nawi (2017) stated that process innovation is crucial in the construction industry, the study findings were consistent with those of Cheng, Yang and Sheu (2014), Gambatese and Hallowell (2011) and Kesidou and Demirel (2012). Organisational EI did not directly minimise the negative environmental impacts, but it acted as an implementation platform to boost process EI and product EI (Cheng and Shiu, 2012). Currently, contractor firms implement a minimum level of EI, which is only sufficient to fulfil the environmental requirements at minimum cost allocation. Investment in eco-innovative practices could create new business opportunities and improve firm efficiency to remain competitive in a highly turbulent construction environment. The results implied that contractor firms should first engage in organisational EI by developing the necessary resources and infrastructure. The decision to eco-innovate is mainly influenced by a firm's top management (Kesidou and Demiral, 2012), who continually explore ways to expand and enhance their services. The eco-innovative approach offers competitive advantages to firms. When a firm adopts eco-innovative practices, its overall management improves the construction processes, products, and services.

THE RELATIONSHIP BETWEEN EI PRACTICES AND FACTORS THAT DRIVE CONTRACTOR FIRMS TO ECO-INNOVATE

This study has identified how various driving factors could accentuate the firm's motivation to implement EI effectively. It was conceptualised using data analysis to ascertain whether these factors (firm-specific, technological, environmental, and market factors) influenced the decisions of contractor firms to adopt EI within their firms. The four hypotheses developed for this study were confirmed using the Pearson correlation coefficient analysis. The correlations between the variables obtained showed a moderate to a strong relationship. All variables displayed a positive correlation, which indicates that they move in the same direction.

The result from Hypothesis 1 suggested that EI's complexity requires contractor firms to improve their capabilities and resources to increase EI adoption level and expand their competitive advantages. In recent years, the speed of scientific and technological development has stimulated particular interests among firms to invest in innovations for their resources and capabilities to be improved (Lim and Peltner, 2011). The EI requires more highly intensive innovation (Horbach, Rammer and Rennings, 2012). Thus, firms would improve their services by purchasing new plants and machinery, implementing effective systems, software, advanced green technology, and assimilating green knowledge. This would allow them to meet the growing demands of clients, consultants, and authorities while also reducing negative environmental impacts (Gambatese and Hallowell, 2011; Qi, et al., 2010; Hazarika and Zhang, 2019). Triguero, Moreno-Mondéjar and Davia (2013) argued that technological and managerial capabilities within the firm positively influenced the decision to eco-innovate at the firm level. Li (2014) mentioned that a firm's ability to remain sufficiently profitable is crucial, even though they must also invest in addressing environmental concerns. Thus, contractor firms with sufficient capabilities and resources could adopt eco-innovative practices effectively.

This study confirmed that technological factors significantly positively correlate with EI adoption, which is in line with Hypothesis 2. These findings were consistent with those of other studies by Cheng, Yang and Sheu (2014), Horbach, Rammer and Rennings (2012) and Fernando and Wah (2017), which found that technology is a significant driver and is associated with firms' decisions to adopt EI. The availability of advanced technology allowed the contractor firms to improvise its conventional construction approach to become more sustainable. The environment is greatly affected during the construction stage, hence new eco-innovative measures could reduce operational costs and improve the environment. Furthermore, collaborations between contractor firms and external actors are critical in initiating EI, particularly in identifying alternative and environmentally friendly technologies to implement during the construction process (Cheng and Shiu, 2012; Bamgbade, Kamaruddeen and Nawi, 2017). This finding indicated that technological improvement is the key motivator of EI adoption in reducing the ecological burden of construction projects.

This study also discovered that environmental factors positively correlate with EI adoption, which reflects Hypothesis 3. The importance of adhering to environmental regulations and standards pressured and triggered contractor firms to adopt EI to avoid unnecessary non-compliance penalties. This finding was supported by previous studies of Fernando and Wah (2017), Rennings (2000), and Triguero, Moreno-Mondéjar and Davia (2013), who stated that a firm that practises EI and complies with environmental regulations would improve its environmental performance. Previous studies stressed the importance of an EMS, which facilitates EI adoption and continuously improves their eco-practices whilst complying with environmental requirements (He, et al., 2018; Kesidou and Demirel, 2012, Horbach, 2008). In turn, it helped contractors to improve their environmental performance, evade any financial penalties for non-compliance, and create a better corporate image and reputation.

Market factors also have a significant positive relationship with EI adoption by contractor firms, which is Hypothesis 4. When there is an increase in demand for green buildings and eco-products, contractor firms respond positively to meet the demand. This outcome was supported by Triguero, Moreno-Mondéjar and Davia (2013) and Kesidou and Demirel (2012), who showed that firms initiate EI to satisfy the market and client requirements. This suggests that a strong sense of market orientation from clients and end-users can encourage contractor firms to develop and implement practices that support the delivery of eco-friendly buildings in line with their customers' demands. Cai and Li (2018) revealed that the market-based instrument is an influential factor in encouraging EI practices. Clients' green development actions are influenced by the market situation and end-user demand (Abidin, 2010). Increasing customer demand for sustainable buildings would induce clients to improve specifications and include certain green elements to attract buyers. Thus, developers were encouraged to obtain and comply with voluntary green rating tools in their development projects (Bohari, et al., 2015; Abidin, 2010). These would enable the contractor firms to benefit from being the first adopter in the market by using eco-products and materials in construction projects. This scenario influenced contractor firms to adopt EI in their construction practices.

Conclusions

The severe environmental threats resulting from construction and development projects triggered contractor firms to support sustainable growth through eco-innovative approaches in their effort to remain competitive and relevant. Although there is a growing interest in EI adoption in the manufacturing industry, the pace of EI adoption in the construction industry has remained moderate. This study contributed significantly to the existing knowledge and deepened the overall understanding of EI adoption practices and motivational factors influencing contractor firms to enhance their services eco-innovatively. In terms of practical contributions, this study revealed that organisational EI is crucial in contractor firms' adoption of process EI and product EI. Corporate investments in process EI and product EI would not be practical without the necessary procedures and managerial support. Senior management teams could make significant improvements by assessing the existing conditions of EI adoption to improve their environmental performance. This would include investing in technology and enhancing human resource efficiency or certification. Thus, to ensure the successful implementation of EI, firms need knowledgeable and concerned managers relating to environmental issues. Providing training, education, and incentive instruments could encourage employees to commit their effort and skill to environmental initiatives.

Generally, the results showed that all the driving factors have a significant positive relationship with EI practices by Malaysian contractor firms. The results revealed that if all these factors increase, the adoption level of EI practices in the process, product, and organisational contexts would be substantially enhanced. Thus, this outcome would enable more effective decision-making by top management. They could respond to factors that motivate their growing adoption of eco-innovative practices at the firm level. Recognising the EI driving factors from the contractor firms' perspectives would help policymakers and governments develop economic instruments that encourage EI practices in the Malaysian construction industry. The study's findings indicated that governmental environmental regulations have a substantial impact and promote the adoption of EI in the construction industry. The government needs to be proactive in providing green infrastructure and knowledge-based training to promote eco-competitive strategies in the construction industry. It is imperative for contractor firms to use environmental-friendly technology and resources to find an equilibrium between improving their EI performance, fulfilling their clients' desires and requirements, and remaining financially viable. The study results discovered that contractor firms targeted improvement in their capabilities and resources by using technology factors, contributing significantly to EI adoption. The improvements included producing technology-savvy employees, using the government's available incentive for technology R&D and collaborating effectively with external actors. These improvements continuously enhance a firm's technological capabilities and knowledge to embrace eco-innovative practices, consequently leading firms towards environmental sustainability.

This study has several limitations. It offered a limited generalisation regarding data collected from participants from contractor firms with grade G7 in Malaysia. The requirement to comply with environmental sustainability utilising eco-innovative practices is crucial for all contractor firms involved in the Malaysian construction industry. It is beneficial to collect similar data types obtained from contractor firms of various grade categories. For future recommendations, further investigation is required to explore ways to enhance the capabilities of all contractor firms in advancing EI within their business strategies. The study findings helped formulate a framework for strategies that enhances EI adoption among contractor firms to achieve environmental sustainability. Qualitative research approaches could assist researchers in the formulation of strategies. The obtained results justify further exploration of EI implementation at the project level. Additional studies might explore practical ways to better understand EI adoption and development from other project stakeholders or other industries' perspectives.

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