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Green supply chain management: An empirical investigation on the construction sector

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Abstract

Purpose: Curtailing the adverse environmental impacts of the construction sector is one the major challenges of the twenty-first century. However, despite the significance of this problem, the limited efforts so far to tackle the negative impacts associated with this particular sector have been largely fragmented and disjointed. Given that the net green outcome of a construction project is the sum total of the efforts undertaken at the various supply chain stages (from the initial design to the end-of-life demolition) by different stakeholders, the green supply chain management (GSCM) approach is seen as a way forward toward streamlining the fragmented efforts at greening the sector. This forms the motivation of the present work, which aims to develop, validate, and apply a multi-dimensional GSCM framework for the construction sector.

Design/methodology/approach: A comprehensive GSCM assessment framework consisting of nine constructs (external and internal drivers; external and internal barriers; core and facilitating GSCM practices; economic, environmental and organizational performance implications) and their underlying factors was developed through an extensive literature review. Using data collected through a structured questionnaire, the framework was validated, and the relevance/appropriateness of each construct and its underlying factors, along with the hypothesized relationships between the constructs, were assessed separately for each supply chain stakeholder.

Findings: The findings confirm the validity and reliability of the constructs and their underlying factors as well as the assessment framework. In general, the implementation of green practices has had a positive impact on the environmental, economic, and organizational performance for all stakeholders, while the extent of the green practices implemented depends on the relative strength of the drivers and barriers.

Research limitations/implications: This study fills a gap in the literature about applying/implementing GSCM in the construction sector.

Practical implications: The findings provide practitioners, policy makers, and organizations associated with the UAE construction sector, as well as the construction sector in general, insight into all key aspects of GSCM.

Originality/value: A comprehensive survey-based assessment of GSCM for the construction sector has not been previously attempted and constitutes the novelty of this work.

Keywords: Green supply chain management, Construction sector, GSCM framework, United Arab Emirates

Paper type: Research paper

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1. Introduction

Climate change due to rising greenhouse gas (GHG) emissions and resource depletion is one of the major challenges of the twenty-first century (UNEP, 2010). Among other factors, the construction sector is the single largest contributor, responsible for one-third of global carbon emissions, one-third of global resource consumption, 40% of the world's energy consumption, 40% of global waste generated, and 25% of the world's total water consumption (UNEP-SBCI, 2016). With 66% of the world's population expected to live in urban areas by 2050 (UN-DESA, 2014), the CO_2 emissions from this sector alone are projected to reach 15.6 billion metric tons by 2030, almost double the 2004 estimates (Levine et al., 2007). Left unchecked, our planet cannot handle this level of growth and its associated impacts. Therefore, immediate actions for greening the construction sector are essential for ensuring the survival of future generations (UNEP, 2014).

Though researchers, governments, and practitioners have made efforts to tackle the negative impacts associated with this sector, most of these attempts have been largely fragmented and disjointed, looking mainly from an individual stakeholder's point of view, such as the Developer (Abidin, 2010) or the Contractor (Qi et al., 2010) and covering only a small number of supply chain issues in isolation such as green transportation (BRE, 2003), green purchasing (Varnas et al., 2009), or management issues such as "drivers" of green practices (Qi et al., 2010) or "barriers" to green purchasing (Sourani and Sohail, 2010). As a result of this lack of holistic understanding, there is a risk that practitioners and policymakers could mistakenly be addressing the wrong issues and neglecting aspects that have more significance. Given the net greening of a construction project is the sum total of efforts undertaken at the various supply chain stages by various stakeholders (from the initial design to the end-of-life demolition), the comprehensive greening of a project (and subsequently the sector) can only be achieved if the key supply chain stakeholders, namely the Developers, Architects/Consultants, Contractors, and Suppliers (UNEP-SBCI, 2014), are able to harmonize their conflicting interests and implement green practices in a coherent manner with each other (Compact, 2010).

At present, no studies published thus far on the construction sector have been able to provide a comprehensive and systematic green investigation covering the various supply chains stages and supply chain stakeholders (a green supply chain management (GSCM) approach) in order to address the relevant issues, such as: (1) what green practices stakeholders implement; (2) what the drivers/motives of stakeholders are for implementing such practices; (3) what the barriers/challenges faced by stakeholders are in the implementation of these practices; and (3) what implications these practices have on their (stakeholder's) performance. Given that other sectors, such as general manufacturing and automotive industry, have benefited from GSCM-related investigations (Malviya and Kant, 2015), a holistic GSCM-oriented study on construction could provide a comprehensive understanding of the various conditions necessary for greening the sector.

This formed the motivation of this research, which aim to develop and validate a multidimensional GSCM framework for the construction sector covering all of the key supply chain stages and accounting for the roles of the various stakeholders (in this paper 'stakeholders' refers to the main supply chain stakeholders namely, Developers, Architects/Consultants, main/sub-Contractors and material/equipment Suppliers) and apply the framework to comprehensively assess the GSCM aspects of the construction sector.

The specific objectives of this GSCM study on the construction sector are as follows:

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1. To develop the relevant GSCM constructs;
2. To develop a comprehensive GSCM assessment framework that captures the interrelationships between the constructs;
3. To empirically test and validate the framework.

We have carefully chosen the United Arab Emirates (UAE) as a case country to test and validate the framework due to several characteristics of its construction sector. For instance, the country's construction sector, which is home to some of the most innovative buildings, skyscrapers, and man-made islands, has played a pivotal role in the last decade in the growth and transformation of the UAE from a nomadic country to a modernized country. But, this unprecedented growth has been a cause of significant environmental degradation (around 75% of all the solid waste generated in UAE are from construction sector (SCAD, 2013)), including carbon emissions, which at one point was the highest in the world (World Bank report of the UAE, 2008). However, this also had compelled UAE government and construction firms to take significant efforts towards reducing the negative environmental impacts of the sector. As a result, the UAE construction sector in the past few years have seen significant improvement in green practice application, as evident from the increase in number of LEED certified projects (from few in 2011 to more than nine hundred in 2015 according LEED (2015) statistics). Therefore, the UAE provides a perfect example for understanding the adverse impacts of urbanization as well as the potential opportunities to lessen the impacts associated with it. Given that the underlying attributes of construction sectors are similar across countries, the lessons learned from this study can provide significant insights on "greening" the sector for practitioners and policymakers elsewhere in the world, which are in a similar position, i.e. witnessing significant construction growth and facing associated environmental concerns.

The remainder of the paper is structured as follows. In the next section, the construction supply chain including the role and responsibility of each stakeholder is introduced. In the third section, we investigate the green-related studies in construction in conjunction with GSCM studies in other sectors as a background for developing the GSCM constructs. In the fourth section, a GSCM framework for the construction sector is proposed. In the fifth section, the research methodology undertaken to assess the validly and reliability of the constructs and for testing the framework is explained. The analysis and findings of the study are provided in the sixth section, followed by discussion and conclusion in the final section.

2. Construction supply chain

In stark contrast to the unilateral, long-term transaction relations representative of the manufacturing supply chain, the construction supply chain is highly complex, diverse and fragmented that involves a multitude of stakeholders participating in dyadic relationships (Rezgui and Miles, 2009). For instance, on a large construction project, the number of organizations involved in the supply chain can run into hundreds, if not thousands. Also, the sector is characterized by one-off contracts and a failure to develop longer-term relationships between stakeholders (Dubois and Gadde 2000; Briscoe et al., 2001). Moreover, the construction supply chain has a reputation for low-trust and adversarial trading relations between supply chain stakeholders (Korczynski, 1996; Akintoye et al., 2000). For instance, Latham (1994) highlighted the adversarial attitudes that commonly exist between main Contractors and their Suppliers. The lack of uptake of GSCM in construction vis-à-vis other sectors is mainly due to the insufficient attention being paid to the complex, diverse and project-driven construction environment including the key stakeholders involved.

Hence to facilitate the application of GSCM in construction, it is important to conceptualize the construction supply chain in terms of how the order/information flow through the supply chain as well as how the materials/deliverables flow in the supply chain. Figure I shows a typical construction supply chain.

Figure I

As seen in figure I, Developer is the one who initiates the project. Due to this very reason, they are vital for creating green supply chains as their green building requirements itself will play a pivotal role in the green behavior of other downstream supply chain stakeholders. In a typical construction supply chain, Developer appoints Architects/Consultants to be their client representative, to supply both design and any specialist management services such a preparation of tender documents, technical evaluation of tender bids for the selection of the main Contractor and final commissioning of the projects. The main Contractor is selected by the Developer based on the technical (typically evaluated by the Architect/Consultant) and commercial proposal (typically evaluated by Developer). Once the main Contractor is selected, based on their capabilities, they either carry out the construction activities themselves or hire specialist sub-Contractors to perform specific activities such as the installation of building façade, HVAC systems, building management systems (BMS) etc. Finally, both the main Contractor and sub-Contractor will have to rely on several Suppliers, to provide them with raw materials and equipment's to carry out their required activities.

Regarding material flow/deliverables, the raw materials such as cement, pre-fabricated components such as glass façade, systems such as HVAC are processed and assembled onsite by the main/sub-Contractors. Upon completion of the building, the final commission of the building will be executed by Consultants, and non-compliance (if any) at this stage is reverted to the main Contractor to rectify to get the building commissioned. After commissioning, the building is handed over to the Developer and is ready for occupation.

This information and material flow perspective of construction supply chain clearly demonstrate that comprehensive greening of a construction supply chain requires the involvement of all key supply chain stakeholders and the laggardness of even a single stakeholder can adversely impact the overall greening efforts.

Though most of the previous studies are narrowly scoped, the fragmented contributions of these various works when taken together, have many of the critical aspects necessary for the development of a common conceptual base towards successful management of green supply chains.

Also, despite the differences that exist with other sectors, the construction sector could still benefit from 'borrowing' best practices and management ideas such as GSCM from other sectors provided they be carefully crafted and contextualized (Harty 2008; Kumaraswamy et al. 2008). For instance, aspects such as "supply chain partnering" and "supply chain collaboration", which is common in other sectors such as manufacturing are now seen in the construction sector. For example, Developers have begun to enter into partnerships with the major contractors and these contractors

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are exploring the possibilities of extending partnering/collaborative agreements down the supply chain to key material Suppliers and subcontracting firms (Tennant and Fernie, 2014).

3. Developing GSCM constructs and items for the construction sector

Construct development and validation are essential for the establishment of a common conceptual base, especially when there is a lack of agreement on how the scope of GSCM is defined in the literature (Ahi and Searcy, 2013). Given the contributions of various studies that exist in isolation, a comprehensive and in-depth synthesis of the fragmented body of green-related work spanning the construction sector has enabled us to identify the critical constructs for each of the major supply chain stakeholders (Developers, Architects/Consultants, Contractors, and Suppliers). Also, the synthesis of the literature in construction has been carried out in conjunction with a larger body of GSCM literature in other sectors, such as general manufacturing, which have seen significant progress in the last decade or so, in order to avoid any important omissions and to ensure that the constructs developed are managerially relevant, though the specific items within the constructs may vary depending on both the industry and country in question. The GSCM constructs and its underlying items, and their relevance for each stakeholder (indicated by ✓) are summarized in Table I.

Take in Table I

While it may be argued that a host of other constructs and items could be identified in the GSCM literature, no other constructs appeared to be as consistent and relevant in the extant literature as those summarized in the table.

3.1 Green practices

These are practices carried out by firms to minimize the negative environmental impacts associated with their activities. The objective here is to identify the relevant green practices related to each of the supply chain stakeholders. Based on our understanding of these practices in construction and other sectors, we classified these practices into "core green practices" and "facilitating green practices" depending on the level of implementation.

3.1.1 Core green practices

These are practices undertaken at the supply chain level, covering each of the major stages of the supply chain. The operational stage is not considered within the scope of this paper, since it is largely covered by green design, given that an energy-efficient design could significantly reduce the environmental impacts during the operational phase of building, as well as eliminate the need for costly and disruptive refurbishments for reducing any environmental impacts during the post-occupancy stage (Fieldson et al., 2009; Li and Colombier, 2009). The relevant practices identified are:

- **Green building design**: This is of paramount importance for the sector, as decisions made during this stage will have a significant influence on the life-cycle environmental impact of the building. As highlighted by Zhang et al. (2011), the process should start with an environmental impact assessment of the design to understand any potential effects on the surrounding flora and fauna of the building. Similarly, designers should consider the climate conditions, building structure and shape, and its thermal characteristics (Ng et al., 2012). For example, the provision of natural ventilation and lighting can cut down electricity

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consumption. Similarly, integrating the right technological systems within the building design, such as the use of solar panels, energy efficient heating, lighting and air-conditioning systems, and wastewater recycling technologies, are essential for improving the environmental performance of the building (Zhang et al., 2011). Furthermore, the right choice of materials and components will minimize the negative impacts during construction (e.g., the provision for pre-fabricated components improves constructability and reduces onsite waste) and during end-of-life demolition (as more components and materials can be recovered), in addition to reducing the embodied energy and harmful effects associated with the building (Ng et al., 2012). Developers and Architects/Consultants are the relevant stakeholders involved in green building design. In the case of construction material Suppliers, the corresponding practice is “green product design,” which includes the selection of raw materials with high percentages of recycled content and low embodied energy.

- **Green purchasing:** This includes the integration of environmental considerations into purchasing policies, programs, and actions (Varnas et al., 2009), both in the material purchasing decisions and in awarding the contract. Material purchasing decisions include the purchasing of products with environmentally-friendly features, such as recycled materials and non-toxic ingredients (Ofori, 2000). Similarly, environmental consideration during the tendering stage involves the establishment of environmental criteria in the pre-qualification stage, such as requiring that the tender participant should possess EMS and ISO 14001 certification, technical knowledge including previous green project experience, or LEED certified professionals in the payrolls. In the selection phase, appropriate weights are allocated to the green aspects of the project.
- **Green transportation:** These are practices undertaken to minimize the environmental impacts associated with transportation (BRE, 2003). Construction projects typically have a significant amount of transportation activities, which involve both employee transport and material transport. According to Ng et al. (2012), 6-8% of carbon emitted during a construction project is due to the transportation of materials, and therefore transportation strategies, such as full-truck quantities and fuel-efficient vehicles to minimize emissions, should not be overlooked. Similarly, the use of video conferencing instead of face-to-face meetings, shared and public transport instead of personal transport, and employee accommodations near project sites can reduce employee-related transportation impacts (TemaNord, 2010; BRE, 2003).
- **Green construction/manufacturing:** Green construction refers to use of onsite practices to minimize the environmental impacts of construction. These practices are relevant only to main/sub-Contractors, and involve considerations such as waste management planning (Shen and Tam, 2002), the use of automation (Chen et al., 2010), the implementation of wastewater recycling technology (Shrestha, 2016), the adoption of offsite-prefabrication (Jaillon et al., 2009), the use of fuel-efficient machinery (Shi et al., 2013), and the use of energy efficient and low hazardous materials (Shrestha, 2016). In the case of construction material Suppliers, the corresponding practice is “green manufacturing,” which involves similar practices at the manufacturing sites.
- **End-of-life management:** Carefully-planned and energy-efficient execution of demolition activities is required to maximize the recovery and recyclability of materials (Ng et al., 2012). It is of paramount importance to reduce the environmental burden associated with materials embodied in the building (Thormark, 2002). A case study by Blengini (2009) in Italy

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has shown that end-of-life management can reduce the total life-cycle energy of a building by approximately 30%, and GHG emissions by 18%. For some materials, such as steel or aluminum, recycling can confer savings of more than half the embodied energy as well as significant reductions in the associated GHG emissions (Yan et al., 2010).

3.1.2 Facilitating green practices

In order to efficiently execute each of the "core green practices" outlined above, all stakeholders must implement certain practices at the firm level, practices which is referred to as facilitating/supporting practices (Seuring and Muller, 2008). Given the complex supply chain stages in the construction sector, these facilitating practices in construction need to be more robust than those of any other sector. These practices include:

- **Environmental management systems and ISO 14001 certification:** An environmental management system (EMS) consists of a collection of internal policies, assessments, plans and implementation actions. Organizations that implement EMS identify how their activities interact with the environment, the types of environmental impacts that emanate from different operations, and alternative means of preventing environmental pollution and natural resource degradation (Darnall et al., 2008). While there are different standards for EMS, ISO 14001 is the most widely recognized standard. There is considerable evidence in the construction sector and other sectors on the significance of EMS and ISO 14001 from an environmental/green perspective (Zutshi and Creed, 2014; Seuring and Muller, 2008).
- **Environmental training:** Employee training programs on environmental issues are necessary for improving awareness, knowledge, and competence. These training programs must be provided to employees at all levels of the organization, including managers (Qi et al., 2010) and onsite construction workers (Jaillon et al., 2010). For example, Begum et al. (2009) highlighted that contractors with staff who have participated in waste management training programs have more positive attitudes toward waste management.
- **Environmental auditing:** Implementing a strong auditing procedure is necessary to track non-compliance with green activities, both at the firm level and the project level (Carris et al., 2012). Auditing is also necessary to ensure that environmental targets are being achieved (Carris et al., 2012).
- **Cross-functional integration for greening:** Green practices are integrative and require cross-functional cooperation rather than simply being oriented toward a single function or department (Hsu and Hu, 2008). Construction firms are typically characterized by large numbers of functions and departments. Therefore, to achieve the green goals, coordinated cross-functional teams are required for green-related decision making, appropriate exchange of green-related information, commitment to a common goal through mutual support, and continuous improvement (Adetunji et al., 2008)
- **Green related research and development:** Green-related research and development is important to gain competitive advantage in the marketplace (Carris et al., 2012). For example, Carris et al. (2012) emphasized that the Suppliers have played an important role in developing innovative green products and bringing these to the attention of Architects/Consultants and Contractors. Similarly, Architects/Consultants, through research and development, can effectively introduce innovate design solutions.

3.2 Drivers of green practices

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The important drivers or motivating factors for firms to implement green practices can be classified as external or internal, depending on the origin (Walker et al., 2008; Walker and Jones, 2012). Given the different roles and conflicting interests of supply chain stakeholders, the relevance and importance of these drivers could vary depending on the views of the individual stakeholder.

3.2.1 External drivers

These are pressures faced by the organization from outside entities, such as governments, supply chain stakeholders, competitors, and end-consumers. The external drivers relevant for the construction sector can be identified as follows:

- **Government green-related regulation:** Governments worldwide have introduced several regulations to reduce the environmental impacts of construction, such as by establishing environmental standards for materials and technologies (Shi et al., 2013), implementing stringent fines for non-compliance and environmental accidents (Tam et al., 2006; Qi et al., 2010), and imposing landfill taxes (Pitt et al., 2009; Jaillon et al., 2009). A recent survey-based study by McGraw-Hill Construction also highlighted this overwhelming influence of the government in institutionalizing green construction projects worldwide (WGBT, 2013).
- **Stakeholder pressure:** The specific needs and expectations of stakeholders can drive the green practices of other stakeholders in the supply chain. Robin and Poon (2009) demonstrated that these pressures are hierarchical in nature, usually flowing from Developer to Supplier in the supply chain. For example, recent studies in other countries have shown that implementing green practices is one of the most important requirements of Developers for Contractors in the project tender, a shift away from the conventional cost-based awarding system (Qi et al., 2010). As a result, Consultants and Contractors, in turn, are pressuring sub-Contractors and Suppliers into implementing green practices.
- **Competitor pressure:** Pressure from competitors can impact the green practices of firms. Ofori et al. (2000) found competitor pressure to be one of the main drivers of green practices in the Singapore construction sector. Similarly, there is evidence in other sectors showing the influence of competition on the development of firms' green practices (Zhu et al., 2005)
- **End-consumer pressure:** End-consumers are tenants/owners of the building/apartment. Since they engage directly only with the Developer, the consumer pressure as a driver to implement green practices, therefore is only relevant to Developers. However, little is known about the extent of end-consumer pressure faced by Developers in the construction sector, though it is found to be one among the major drivers of green practices in others sectors such as general manufacturing (Sarkis et al., 2011).

3.2.2 Internal drivers

These are pressures that can arise from within the organization to implement green practices. Though firms implement green practices as part of their own environmental commitments, it is widely acknowledged that many do so to achieve clearly-stated business benefits (Varnas et al., 2009). Some of the underlying drivers identified for the construction sector are:

- **Environmental commitment:** A firm's commitment to protecting the environment has been found to drive their green practices in many cases. Embracing green practices is usually seen as a voluntary obligation that is consistent with the values of the society in which the firm functions (Hsu et al., 2013). Usually, this commitment is demonstrated by the decisions of

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top management, which are then communicated through the organization's environmental vision and mission statements, and the specific environmental policies regarding the goals that are to be achieved (Qi et al., 2010; Tan et al., 2011).

- **Enhance reputation/brand image:** The need to improve brand image and reputation is a strong driver for firms to implement green practices, as an enhanced green reputation/image is expected to attract additional investors and buyers. A previous study by Zhang et al. (2011) found that Developers in China who have improved their green reputation and image through the implementation of various green practices had attracted many high-income earners and obtained higher selling prices. Similarly, Shi et al. (2013) highlighted the growing enthusiasm among Contractors to implement green construction practices in attempts to improve brand image and reputation.
- **Reduce costs:** Construction firms are increasingly becoming aware of the potential for cost reduction with green practices, despite the high upfront capital cost of green equipment and technology. For example, Contractors can reduce the costs associated with transportation, labor requirements, installation time, and waste management (Carris et al., 2012).
- **Enter foreign markets:** Entering foreign markets is a significant driver of green practices, as firms are implementing green practices to meet the increasing low carbon regulatory requirements of foreign governments as well as foreign clients' and partners' increasing demands on environmental expertise (HM Government, 2013). Furthermore, the global green and sustainable building industry have been forecasted to grow at an annual rate of 22.8% by 2017 (IBISWorld, 2012).

3.3 Barriers to green practices

Firms may face the same amount or even more green barriers than drivers (Carter and Dresner, 2001). Similar to drivers, green barriers can be classified as either external and internal based on their source of origin (Walker et al., 2008; Walker and Jones, 2012).

3.3.1 External barriers

These are obstacles that are beyond the firm's locus of control. The identified barriers for the construction sector that adversely affect the implementation of green practices include:

- **Shortage of green professionals**: The implementation of green practices requires professionals with expertise in the green industry. Previous studies have found this to be one of the main barriers for greening the construction sector (Ofori et al., 2002; DBIS, 2013).
- **Shortage of green suppliers:** To implement green practices, firms are dependent upon green materials provided by Suppliers. Firms are reluctant to implement green practices if these materials are not available from the standard distribution network. This is due to the fear that a reliable supply network regarding delivery commitment, flexible payment terms, and reasonable pricing cannot be ensured with unknown Suppliers (Shi et al., 2013).
- **Tight and inflexible stakeholder deadlines:** Developers are expected to initiate projects with a faster turnaround time (from conception to handover) especially if the demand is expected to outstrip supply. Since implementing green practices in the construction sector is a more time-consuming process than traditional practices (Hwang and Tan, 2012), the tight and inflexible stakeholder deadline imposed by Developers will flow downstream in the supply chain, compromising the greening efforts of all of the supply chain stakeholders.
- **Lack of stakeholder engagement/collaboration:** Stakeholders' tendencies to hold on to their green knowledge (in order to keep their competitive advantage intact) can prevent

early engagement of stakeholders at the conceptual stage for sharing ideas and best practices. This limitation is further fueled by the fact that there is a lack of long-term partnership agreements, such as Developer-Consultant or Contractor-Supplier, as most agreements are unique and one-off in nature until project completion (Morledge et al., 2009), resulting in a lack of trust based on a contingent social relationship. Liu et al. (2012) highlighted that poor communication between stakeholders arising from lack of engagement is a significant barrier to implementing green practices.

3.3.2 Internal barriers

These are resource-based challenges that arise from within the organization. Two important barriers identified that are relevant to the construction sector are:

- **High cost of implementation:** The additional cost incurred for implementing green practices poses a significant challenge for all stakeholders as highlighted by several studies in construction and other sectors (Zhang et al., 2011; Liu et al., 2012; Seuring and Muller, 2008)
- **Lack of knowledge and awareness:** As evident from several studies in the construction literature (Sourani and Sohail, 2011; Zhang et al., 2012), a lack of knowledge and awareness about green practices and its benefits is a significant barrier stopping firms from investing time and resources in implementing green practices.

3.4. Performance measures

Performance measures play a major role in the success of firms, that includes establishing objectives, evaluating performance, and determining future courses of action (Gunasekaran et al., 2004). In the case of GSCM, though achieving environmental performance targets is the primary objective (Zhu and Sarkis, 2004), given the fact that considerable investment is required for implementing green practices, companies who concentrate solely on being excellent in environmental performance could run the risk of disequilibrium in their short-term and long-term financial performance. Therefore, there is a need to achieve balance between environmental achievements, short-term financial performance (i.e., reduction in material or energy costs), and long-term financial performance (i.e., organization performance in terms of profitability and market share) to meet the expectations of a wide range of shareholders (Green et al., 2012). Given that these measures should be easy to understand and implement for all supply chain stakeholders (Gunasekaran et al., 2004), using the existing literature, we developed a set of measures for construction sector as follows:

3.4.1 Environmental performance

Though several environmental performance measures are highlighted in the construction literature, no other measures have emerged as being more consistently reported and relevant as the following:

- Reduction in environmental accidents;
- Reduction in greenhouse gas emissions;
- Reduction in water consumption;
- Reduction in energy consumption;
- Reduction in landfill waste;
- Reduction in material use;
- Reduction in hazardous material use.

3.4.2 Economic/cost performance

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Similar to environmental performance, several economic/cost performance measures are highlighted in the construction literature. The most relevant are:

- Reduction in material expenses;
- Reduction in water expenses;
- Reduction in energy expenses;
- Reduction in waste management costs;
- Reduction in environmental penalties and fines.

3.4.3 Organizational performance

Thus far, the construction industry has overlooked the organizational performance of green practices, despite firms recognizing aspects such as brand image as a driver. Given that green-related investments have both revenue and cost implications, we believe that organizational performance is relevant for construction, as it provides a composite and long-term picture on the benefits of green practices (Lee et al., 2012; Green et al., 2012), thereby enabling investments in these practices to be justified. The relevant measures for construction borrowed from other sectors include:

- Increases in sales revenue;
- Increases in selling price;
- Increases in market share;
- Increases in return on investment;
- Increases in profits.

These nine GSCM constructs form the shell of the intended GSCM framework. No previous studies in any sector let alone construction have systematically and comprehensively identified the relevant constructs of GSCM in as much detail as this study, and therefore this in itself is a significant contribution given that construct development is at the core of theory building (Venkatraman, 1989).

4. Framework development and hypothesis

As mentioned earlier, most of the previous green-related studies in construction have examined various issues in isolation. The interconnected nature of the constructs implies, assessing these interrelationships are important to understand better the scope of both the problems and the opportunities associated with GSCM across stakeholders. Theoretical frameworks provide a way to conceptualize these complex relationships. Given that no GSCM related framework is available in the construction sector, this study will attempt to develop a comprehensive GSCM framework for construction. Though fragmented, the existing GSCM frameworks available in the generic literature provides a useful starting point towards the development of a GSCM framework in construction. In the process, any gap in the generic literature is addressed.

The review identified two theoretical frameworks proposed by Seuring and Muller (2008) and Carter and Rogers (2008), which can be applied in different contexts including construction. The framework proposed by Seuring and Muller based on the review of 191 journal articles from 1994 to 2007 looks at the pressures and barriers facing focal companies in implementing GSCM, supporting/facilitating practices for the effective implementation of GSCM and the various performance dimensions of GSCM. The framework proposed by Carter and Rogers (2008) includes the integration of environmental, social, and economic criteria. While these frameworks provide a good theoretical background on the meaningful relationships that need to be assessed in GSCM, these are by no means comprehensive as the field has significantly advanced since 2008. To complement these

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theoretical frameworks, the review also identified several empirical assessment frameworks which investigated the relationships between GSCM constructs. One shortcoming of these empirical assessment frameworks is the lack of comprehensiveness, as most frameworks have only looked at the dyadic relationship between GSCM aspects. For instance, frameworks proposed in these studies (Zhu and Sarkis, 2004; Zhu et al., 2007; Rao and Holt, 2005; Green et al., 2012; Zailani et al., 2012; Lee et al., 2012; Laosirihongthong et al., 2013) have looked at only the relationship between green practices and performance. Others have only looked at the relationship between green drivers and green practices (Lee, 2008; Hsu et al., 2013; Ben Brik et al., 2013; Lee at al., 2013). Also, despite several calls in the literature (Seuring and Muller, 2008; Carter and Dresner, 2001), none of the studies has empirically assessed the relationship between green barriers and green practices. This study will attempt to address these gaps and contextualize the critical relationships relevant for construction in a single comprehensive GSCM framework for the construction sector. This will significantly contribute towards the advancement of the GSCM in construction and in general as developing/ extending available frameworks constitutes a possible future avenue for knowledge to grow in a consistent manner in the field (Touboulic and Walker, 2015). According to Carter and Easton (2011), combining existing frameworks into a comprehensive framework allows investigation of multiple theoretical perspectives simultaneously and help define the boundaries of the field more rigorously.

The important relationships between GSCM constructs that constitute the framework for construction sector are explained in the following section. The comprehensiveness of the proposed GSCM framework in construction is ensured to the extent possible provided the framework developed is: a) based on strong theoretical foundation of the existing frameworks b) contextualized based on the author's understanding of the construction sector and c) any gaps/pitfall in the existing frameworks in other sectors is addressed.

4.1. Drivers and practices

Since we have identified the two distinct categories of pressure groups (external and internal) that influence firms' green practices (core and facilitating), we now need to know the extent of the impact that each of these pressure groups has on the green practices of each stakeholder. This understanding is critical given the variance in green practice implementation is related to the strength of these driving forces (Darnall et al., 2009). Studies have shown that the relationships between external drivers and green practice can work both ways. For example, government regulation can positively impact green practice implementation (Lee, 2008) as firms implement green practices out of fear of compliance, fines and legitimacy. Conversely, government regulation can narrow organizational choices on green practice implementation and hence the ability to implement the best possible green practices can be compromised (Zhu et al., 2013). Studies have also shown a heterogeneous response to these various external pressures, where some have found that regulatory pressure, but not customer pressure to impact green practice implementation (Lin and Ho, 2011) while others have found all these pressures to impact green practices implementation (Lai et al., 2011). Thus, there are situations where positive, negative, and no relationships that may exist between various pressures and the extent of implementation of green practices.

On the other hand, firms also implement green practices due to their environmental commitment or/and for achieving clearly identified business benefits (Varnas et al., 2009). These internal pressures will be high for proactive firms and low for reactive firms. Ideally, from a construction sector perspective, a balance should be achieved between external and internal pressures. Firms

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implementing green practices solely from external pressure may not be sustainable in the long run. Understanding whether the sector is reactive or proactive can be made based on the impact of external and internal pressures on green practice implementation. Therefore, understanding this relationship is useful for practitioners and policy makers to undertake necessary steps to the maximize green practice implementation across the sector. For instance, government regulation can be tightened to increase the external pressure on firms to implement green practices. Similarly, awareness campaigns on the business benefits can improve the internal drive of firms to implement green practices.

Hence the following hypotheses are proposed:

H1: External drivers positively impact core green practices.

H2: External drivers positively impact facilitating green practices.

H3: Internal drivers positively impact core green practices.

H4: Internal drivers positively impact facilitating green practices.

4.2. Barriers and practices

Barriers limit the ability of firms to implement green practices. Assessing the impact of these external or internal barriers on green practices would help the sector prioritize the necessary steps required to mitigate/minimize the barriers. However, not much work on understanding this relationship has been done in any sector, including construction, though the impact is generally expected to be negative. For the construction sector, if the impact of external barriers to green practices is high, priority should be provided to attract green professionals and Suppliers to the region and encourage stakeholder collaboration and realistic project deadlines. Conversely, efforts should be focused on improving the knowledge and awareness level of the firms as well as providing incentives and subsidies for firms, especially those struggling to cope with high cost of green practice implementation. For instance, any efforts to reduce the price of green materials and technology could minimize the impact of internal barriers to green practice implementation.

Assessing this relationship is as important as the previous one since it is the net outcome of the opposing pressures of drivers and barriers which determine the extent of green practice implementation (Carter and Dresner, 2001). Hence, we posit the following hypotheses:

H5: External barriers negatively impact core green practices.

H6: External barriers negatively impact facilitating green practices.

H7: Internal barriers negatively impact core green practices.

H8: Internal barriers negatively impact facilitating green practices.

4.3. Core and facilitating green practices

In other sectors, this relationship has been observed to be significantly positive, such as in the case of US manufacturing firms (Green et al., 2012) and automotive firms in Spain (Gonzalez et al., 2008), with Zhu et al. (2013) suggesting the need to implement facilitating green practices in advance of the core practices. For the construction sector, knowledge of this relationship would enable the respective green practices to be appropriately sequenced and applied to realize overall efficiency and effectiveness in implementation, and therefore we propose the following hypothesis:

H9: Facilitating green practices positively impact core green practices.

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4.4. Practices and performance

The *raison d'être* for implementing green practices is that they should improve a firm's environmental performance. While this relationship between green practices and environmental performance has not been investigated in the construction sector, there is considerable evidence in the literature on other sectors that green practices positively improve environmental performance, but with varying extent (Zhu and Sarkis, 2004; Green et al., 2012). From a construction sector perspective, assessing and comparing the strength of the impact of the different green practices (core and facilitating) on environmental performance is important to understanding whether or not green investments are achieving the desired environmental goals. Hence, we proposed the following hypotheses:

H10: Core green practices positively impact environmental performance.

H11: Facilitating green practices positively impact environmental performance.

Similarly, as mentioned above, firms implement green practices not only to achieve their environmental objectives but also to achieve other business goals, such as improved cost/economic performance. Ideally, firms must achieve this ''win-win'' situation to rationalize the investment in green practices. However, there is little consensus in the literature that green practices necessarily lead to improved cost/economic performance (Green et al., 2012; Zhu and Sarkis, 2004). Again, assessing this relationship is important for the construction sector, because if found to be positive, it will provide the strong impetus for firms to implement green practices. This led us to propose the following hypotheses:

H12: Core green practices positively impact economic performance.

H13: Facilitating green practices positively impact economic performance.

Finally, a firm's investment in green practices may not necessarily be environmental or cost-driven, but reputation-driven. Firms are investing in green practices to enhance their corporate/brand image, as it ushers in a tremendous marketing advantage resulting in improved organizational performance, including increased sales and market share; such firms are thus poised to expand their markets or displace competitors that fail to implement green practices (Rao and Holt, 2005). However, there is again little consensus in the GSCM literature on the impact of green practices on firms' organizational performances (Green et al., 2012; Ortas et al., 2014). Assessing this relationship is important for the construction sector, and again, if found to be positive, will provide a strong business case for firms to invest in green practices. Hence, we posit the following hypotheses:

H14: Core green practices positively impact organizational performance.

H15: Facilitating green practices positively impact organizational performance.

To summarize, the nine GSCM constructs and the fifteen hypotheses proposed together complete our GSCM framework for the construction sector, as shown in Figure II.

Take in Figure II

Since we were testing each of these hypotheses separately for each of the four stakeholders, and that the two hypotheses involving the economic performance construct are not relevant for Architects/Consultants, we had a total of 58 hypotheses to be tested (15*4 – 2).

Given that no previous studies have developed a comprehensive GSCM framework similar to the one proposed in this study makes this GSCM framework novel in nature, especially in the construction sector where till now no GSCM framework exist.

Now that we have developed the GSCM framework, the next stage is to test and validate the constructs in the framework and examine the proposed hypotheses. The survey-based research methodology employed to achieve this is explained in the next section.

5. Research Methodology

A survey-based approach, which entails the following stages, was used to test the framework and hypotheses in the study:

- **Survey design:** The underlying items within each construct were organized in the form of a survey questionnaire, similar to the ones used by Zhu et al. (2007) and Green et al. (2012), with all questions assessed on a 5-point Likert scale ranging from 1 to 5. Given the fact that we are validating the framework and testing the hypotheses separately for each stakeholder, any non-relevant questions were excluded for each stakeholder.
- **Survey pre-test:** To ensure content and face validity, the survey questionnaire was given to 12 senior managers (three from each stakeholder) and three academics to review the survey instrument, which included checking the appropriateness of each item and construct for each stakeholder, evaluating the readability/choice of terminology, assuring clarity/ease of understanding, and the relevance of the items in real-world business situations. Based on their suggestions, certain modifications were made to the survey instrument.
- **Pilot testing:** A pilot survey test was conducted to gain insight into the planning and preparation of the main survey, including aspects such as the response rate (by stakeholder), the drop-out rate, and average time for completion; in addition, useful feedback were obtained from the survey participants on the survey instrument, which in turn helped us in re-arranging the survey questions and in reducing the survey length.
- **Main survey administration and responses:** The country-wide survey was conducted during the fall of 2015, with the survey instrument administered via email to construction industry professionals in the UAE using Qualtrics, a web-based survey system. Several measures to improve the response rate were undertaken (Dillman, 2000; Frohlich, 2002). A total of 2,401 construction industry professionals from over 200 firms were invited to participate, out of whom 517 completed the survey, a response rate of 21.5%, greater than that recommended in supply chain management research (Prahinski and Benton, 2004; Pagell and Krause, 2004). Of the 517 responses, 62 responses were removed due to incompleteness or concerns related to the respondent's lack of knowledge about green practices (identified from the survey itself), leaving 455 valid responses for data analysis. The characteristics of the survey participants are provided in Table II.

Take in Table II

- **Check for non-response bias:** The responses of early and late participants were compared based on the assumption that the opinions of late respondents are representative of the opinions of the theoretical non-respondents (Rogelberg and Stanton, 2007). A t-test

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revealed no significant difference between the two groups for each of the items, indicating that non-response bias was not a problem in this study (Armstrong and Overton, 1977).

- **Check for common method bias (CMB):** CMB arises in cases where one respondent answers all parts of the self-reported questionnaire involving multiple constructs (Podsakoff et al., 2003). This was tested using Harman's single factor test, one of the most widely-used methods to check for CMB, in which all items are loaded into one construct (factor) using exploratory factor analysis (EFA) (Podsakoff et al., 2003). The results of the constrained one-factor EFA accounted for only 26.1% of the variance, while the unconstrained nine-factor model explained 79.2% of the variance, indicating that CMB was not a major issue in this study.

6. Analysis and Findings

In the first phase of the analysis, the statistical appropriateness of each of the first-order constructs were assessed. First, the unidimensionality of the GSCM constructs for all stakeholders was determined using convergent validity and discriminant validity. Cronbach's alpha was used to evaluate reliability, a method that measured the consistency, precision, and repeatability of the items within the constructs.

- **Convergent validity:** Confirmatory factor analysis (CFA) was conducted separately for each construct using the maximum likelihood approach (O'Leary-Kelly and Vokurka, 1998). The standardized factor loadings of CFA indicate the correlation between the individual items and the corresponding construct. Usually, a higher factor loading (>0.5) and corresponding critical ratio above 1.96 shows evidence of construct validity (Anderson and Gerbing, 1988). As shown in Table III, items measured across the four stakeholders (except for the 12 underlined items) were loaded to their respective construct with factor loadings greater than 0.50 indicating strong convergent validity of the theoretical constructs. The 12 items that failed to load were removed from the subsequent analysis.
- **Discriminant validity:** A series of pairwise CFAs were conducted by forcing measurement items of each pair of constructs into a single underlying construct to check for any significant deterioration of model fit relative to a two-factor model (Anderson and Gerbing, 1988). The pairwise tests were performed for each stakeholder, and the results showed significant deterioration in the model fit for all cases, thereby demonstrating strong discriminant validity.
- **Reliability:** The Cronbach's alpha values of the constructs were well above the limit of 0.70 in most cases, except for the internal barrier construct for Developer, Architect/Consultant, and Supplier, in which the range of values was slightly above the minimum threshold of 0.5 (Nunnally, 1978).

Take in Table III

In the second phase of the analysis, the operationalization of "core green practices" as a higher (second)-order latent construct was tested using second-order confirmatory factor analysis. The results implied that core green practices could be operationalized as a second-order construct, i.e. the relevant first-order constructs, namely green design, green purchasing, green transportation, green construction/ manufacturing (for Suppliers), and end-of-life, management are governed by a

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higher order construct, namely core green practices (see section A of Figure III). The first-order loading for all stakeholders was well above 0.5 and significant at $p<0.05$, demonstrating strong convergent validity. Furthermore, the overall model fit ($\chi2/DF$) and various other goodness-of-fit indices, namely CFI, GFI, AGFI, and RMSEA, were within the acceptable range (Bagozzi and Yi, 1988).

Now that we had validated the first-order and second-order constructs in the GSCM framework, the next phase of the analysis required examination of the descriptive statistics at both the construct and the item level to identify the relative importance of the constructs and items as perceived by the respondents.

6.1. Descriptive Statistics

The composite mean and standard deviation of the constructs are given in Table IV, whereas the mean values of all individual items underlying each construct are given in Appendix I.

Take in Table IV

As shown in Table IV, all stakeholders, except for Developers, were more internally motivated to engage in green practices. In the case of Developers, external pressures, especially from government authorities and competitors, emerged as the dominant drivers for implementing green practices. Still, both the external and internal pressures faced by Developers are relatively lower than those of other stakeholders. Moreover, the high standard deviation (SD>1) for external and internal drivers for Developers indicates considerable variation in the way firms perceive these pressures. While there is a possibility that firm size may have an influence on this variation, a more in-depth investigation is still required to understand the exact reasons behind this variation. The other interesting observation is that Suppliers emerged as the most internally driven among the stakeholders, with a mean score of 4.29. In terms of barriers, both Developers and Suppliers appeared to perceive internal challenges as more significant than external, while in the case of Architects/Consultants and Contractors, the perceived challenges emerged to be more or less the same.

With respect to facilitating green practices, the extent of implementation of Suppliers emerged to be the highest (mean score of 4.25) with a relatively low SD of 0.58, indicating that implementation is high across most Supplier firms. On the contrary, the facilitating practices of Developers emerged to be the lowest (mean score of 3.13) with a relatively high SD of 1.30, pointing to an imbalance in the implementation among different Developer firms. Again, there is a possibility that firm size may have an influence on this variation. For Architects/Consultants and Contactors, the extent of the implementation was moderate, with mean scores of 3.91 (SD=0.87) and 3.62 (SD=0.90), respectively.

In terms of core green practice implementation, Developers emerged as lagging, with the mean scores of all of the four sub-constructs (green design, green purchasing, green transportation, and end-of-life management) being lower than those of the other stakeholders. This lag is especially higher for end-of-life management (mean value of 2.63) compared to Architects/Consultants (mean value of 3.34) and Contractors (mean value of 3.70). Furthermore, the high standard deviation for Developers (1.45) indicates that perhaps only a few Developer firms have actively started to consider end-of-life management. On the other hand, the core green practices of Suppliers emerged as the most significant among stakeholders for all of the relevant sub-constructs. This relatively higher mean score for the Suppliers could be attributed to the fact that green product/material

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development is relatively easier and less complex than the actual green building process itself, the latter of which other stakeholders are directly involved in. The core green practice implementation of Architects/Consultants and Contractors emerged to be moderate and consistent for all of their relevant sub-constructs, with mean scores ranging between 3.34–3.82 and 3.63–3.91, respectively.

Finally, with respect to performance, the perceived improvement in all three performance dimensions for Developers seemed to lag behind other stakeholders, especially with regards to economic performance with a mean score as low as 1.92. The perceived improvement in environmental and economic performance of Suppliers was found to be the highest (mean scores of 4.29 and 3.69, respectively), whereas the perceived improvement in organizational performance emerged to be slightly higher for Architects/Consultants (mean score of 3.41) compared to Contractors (mean score of 3.25) and Suppliers (mean score of 3.32).

However, at a macro level, the most important finding from this analysis is that the mean scores of drivers (external and internal), the extent of practices (core and facilitating), and performance (environmental, cost/economic, and organizational) were lower for Developers in comparison to other stakeholders. This is a grave concern for the UAE construction sector from a greening perspective, given that Developers are the ones who initiate green projects.

Now that we have identified the relative importance of each construct and its items, the relationships between these constructs as hypothesized are examined in the next phase. The following section explains the statistical procedure used for testing the hypotheses as well as the detailed findings.

6.2. Hypothesis testing and results

In this study, despite obtaining 455 usable responses from the survey, we were still faced with a relatively small sample size for conducting a full-fledged structural equation modeling for testing the hypotheses, since each of the relevant hypotheses had to be tested separately for each stakeholder. While the sample size may not have been much of an issue for Contractors (213 responses), the sample size for other stakeholders was relatively low, with Developers (60 responses) having the lowest response rate. To counter this issue of sample size, we adopted path analysis (PA), a special case of structural equation modeling (SEM) in which the relationship between a pair of latent constructs is assessed at a given point in time. This approach is consistent with the prior work of Zhu et al. (2013) in green supply chain management, in which the causal relationships between constructs of interest are considered. SEM software, AMOS 19 version was used to conduct the path analysis. The overall model fit indices and goodness-of-fit indices obtained during the assessment of structural relationships (for each pair of constructs) were well above the acceptable threshold (Bagozzi and Yi, 1988). The hypotheses test results and their significance for all stakeholders are shown in Figure III section B.

Take in Figure III

Drivers and practices (H1-H4): The evidence from the path analysis indicated that all four proposed hypotheses were supported for all four stakeholders (16 relationships in total). However, the value of the path coefficients indicated that the impact of the external drivers on core green practices and facilitating green practices was moderate (range of 0.3 to 0.7), except for the Suppliers, where the path coefficient (β=0.26, $p<0.1$) was below 0.3.Meanwhile, the impact of the internal drivers on core

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green practices ($\beta=0.74$, $p<0.001$) was high (>0.7) for Contractors, and moderate for other stakeholders, whereas , its impact on facilitating practices was moderate for all stakeholders except for Developers. For Developers, low impact ($\beta=0.17$ $p<0.1$) indicates that the extent of the facilitating practices demonstrated was mainly due to external drivers, and based on the descriptive statistics, such practices were most likely employed due to competitor pressure.

Barriers and practices (H5-H8): The path analysis results indicated no significant relationship between perceived importance of external barriers and the extent of implementation of core green practices for Developers ($\beta=-0.18$, $p>0.1$). However, if we analyzed these results more closely, it appears as though this could be because Developers are less impacted by a shortage of green professionals, as most of their core green practices such as green design are outsourced to Architects/Consultants. Similarly, Developers do not perceive a shortage of green suppliers as a major barrier, since it is the responsibility of Contractors to manage their Suppliers. Moreover, since they are the ones who set the project deadlines, they have control over changing deadlines depending on their upfront commitments with prospective buyers (if any). Again, given the fact that Developers are the ones who sit on top of the supply chain hierarchy, they have the power to control stakeholder engagement and collaboration as desired. In the case of other stakeholders, this relationship emerged to be significant ranging from low to moderate, with the impact being the highest for Suppliers ($\beta=-0.57$, $p<0.01$).

With regards to the relationship between external barriers and facilitating practices, the relationship was low to moderate for all stakeholders (β range of -0.13 to -0.34, all significant at $p<0.1$) except for Architects/Consultants, where no significant relationship was seen ($\beta=-0.12$, $p>0.1$). In the same manner, no significant relationship was seen between internal barriers, core practices, and the facilitating practices for Architects/Consultants, possibly because one of the main determinants, "lack of knowledge and awareness," was relatively low for them. Also, the relationship between internal barriers and facilitating practices was not significant for Contractors ($\beta=-0.07$, $p>0.1$), probably due to the relatively lower cost of implementation of facilitating practices vis-à-vis core green practices, which require considerable investment in green equipment, technology, and machinery.

Overall, out of the 16 relationships tested across all stakeholders, five were found to be non-significant, seven were found to be significant with low impact, and only four were found to be significant with moderate impact. These findings are encouraging for the sector, as most of the barriers were not strong enough to change the stakeholder's course of action in terms of green practice implementation despite all of the barriers being perceived as moderate to high (construct mean range of 2.94 to 3.66) by the respondents.

Core and facilitating practices (H9): The test results indicated that facilitating practices had strong and significant positive impacts on the core green practices of Developers ($\beta=0.76$, $p<0.01$), Architects/Consultants ($\beta=0.81$, $p<0.001$) and Contractors ($\beta=0.82$, $p<0.001$), and moderate impacts on Suppliers ($\beta=0.30$, $p<0.01$). This result supports the argument that facilitating green practices is a necessary precursor to the implementation of core green practices.

Practices and performance (H10-H15): The strong positive impact of core and facilitating green practices on environmental performance is a strong indication that firms in the UAE are implementing the right selection of green practices in an efficient and effective manner. Also, the moderate impact found between core green practices and economic performance for Contractors

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and Suppliers is encouraging enough to provide the impetus for other Contractors and Suppliers to implement core green practices. However, no significant impact was found between core green practices and economic performance for Developers (β=-0.21, p>0.1). On the other hand, the positive impact of the facilitating green practices on economic performance was moderate to high (β range of 0.50 to 0.84) and significant across all relevant stakeholders, a strong demonstration of the cost-saving potential of facilitating green practices. Yet, the most interesting findings are the highly positive and significant impact that core green practices have on the organizational performance of firms (β range of 0.71 to 0.84), and the moderate to high positive and significant impact that facilitating green practices have on the organizational performance of firms (β range of 0.45 to 0.75). These findings, in particular, show that "being green pays" in the long run, and should therefore substantially encourage other firms who are doubtful about the benefits of green practices. Furthermore, the positive impact of facilitating practices on each of the three performance aspects across all stakeholders further strengthens the argument that firms should not overlook their implementation.

In summary, out of the 58 hypotheses tested across the four stakeholders, 52 were supported.

7. Discussion and Conclusion

Even though the findings of this study may differ by country, given the fact that most of the underlying issues in construction are similar in most countries, the insights obtained from this study, including the framework, can be used as a good starting point for practitioners and policymakers in other countries to minimize the negative environmental impacts of the sector. Given the fact that no previous studies have evaluated the GSCM aspects of the construction sector in such detail, the findings of this study are both novel and significant.

There are several important research implications of this study. First, the study was able to identify the critical elements of GSCM and develop them into managerially relevant GSCM constructs. Second, we were able to validate each of the GSCM constructs, including the second-order latent construct (core green practices) for all stakeholders. The operationalization of core green practices as a second-order latent construct in itself is a significant research contribution. Given that construct development and validation is at the heart of theory building (Venkatraman 1989), this study significantly contributes toward the theoretical advancement of GSCM. Next, the study was able to integrate the GSCM constructs into an empirically tractable and meaningful GSCM framework. The proposed framework and hypotheses considerably fill the gap in the literature on the lack of consistency in defining the scope of GSCM (Ahi and Searcy, 2013). However, given that GSCM is a relatively new and promising domain, especially in the construction sector, the framework proposed in this study needs to be further strengthened through refinement and validation across different countries. Future researchers could also investigate the influence of firm size and firm ownership on the relative importance of constructs and items, as well as the relationships between the constructs. Furthermore, given the conceptual comprehensiveness of the framework, future researchers from different industrial settings could adapt and use the framework in their respective contexts. In the case of the UAE, the next obvious step for future researchers would be to use multiple case study methodology to test the GSCM framework and hypotheses qualitatively, and to obtain a micro-level understanding of the various aspects.

Significant insights into managerial practice have also been provided. Regarding the key findings by stakeholders, the low internal drive of Developers to implement facilitating green practices is a

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concern, especially given the strong impact of facilitating green practices on core green practices. For Architects/Consultants and Contractors, a moderately high impact of internal drivers on core green practices is a positive sign for the sector, as they could convince Developers to go for green buildings in addition to being strong advocates for others stakeholders on the benefits of implementing green practices. Also, the strong relationship between facilitating and core green practices for both Architects/Consultants and Contractors, shows that the implementation of core green practices depends on the implementation climate (EMS and ISO 14001), absorptive capacity of new technology and processes (environmental training, R&D), and organizational readiness (cross-functional integration, environmental auditing), reaffirming the importance of facilitating practices for the successful implementation of core green practices. For Suppliers, though they are internally motivated, the impact of external barriers is a significant deterrent for their green practices. In addition, a low relationship between facilitating and core green practices shows that they have to realign/revisit their internal implementation climate, the absorptive capacity of new technology and processes and organizational readiness capabilities to facilitate implementation of core green practices. However, the most interesting and encouraging findings for practitioners is the positive relationships between green practices and all three performance dimensions across all stakeholders. This demonstrates the significant “win-win” opportunities for firms that seek to implement green practices in the construction sector.

The unidimensionality of the core and facilitating green practices for stakeholders shows that implementation of green practices requires all-encompassing effort, rather than being oriented toward the implementation of one or two practices in isolation. In light of this finding, the first of its kind, we foresee increased interest among construction firms, at least from the UAE, in implementing green practices. Furthermore, the study provides a unique opportunity for practitioners and policy makers to understand the differences in the underlying motives, challenges, practices, and performance of each stakeholder so that sufficient actions can be taken to improve the greening efforts of stakeholders, especially those who are lagging behind the others. As mentioned earlier, greening the sector requires the efforts of all stakeholders, and the laggardness of even a single stakeholder can adversely impact the greening of the entire sector. Overall, the GSCM framework and the findings obtained can help practitioners better understand, develop, and manage green supply chains.

The study does have some limitations. Even though the study is very extensive in nature, the proposed framework may not have covered every facet of GSCM. For instance, there could be additional country-specific aspects which have not been accounted for. The study also faced the issue of a small sample size, because of which we were unable to run the full-fledged structural equation modeling of the GSCM framework, instead we had to be content with conducting separate path analyses between the various pairs of constructs. The other limitation is the use of perceptual measures for environmental, economic, and organizational performance, though, in this case, this is justified because of the lack of availability of published performance data. If the data becomes available, future research can focus on using actual and preferably more objective data on performance.

Despite the limitations, we believe the application of the proposed framework and the other findings of this study can significantly contribute toward the greening efforts of the sector, as well as toward more theoretical advancement in the field.

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Figure I A typical construction supply chain

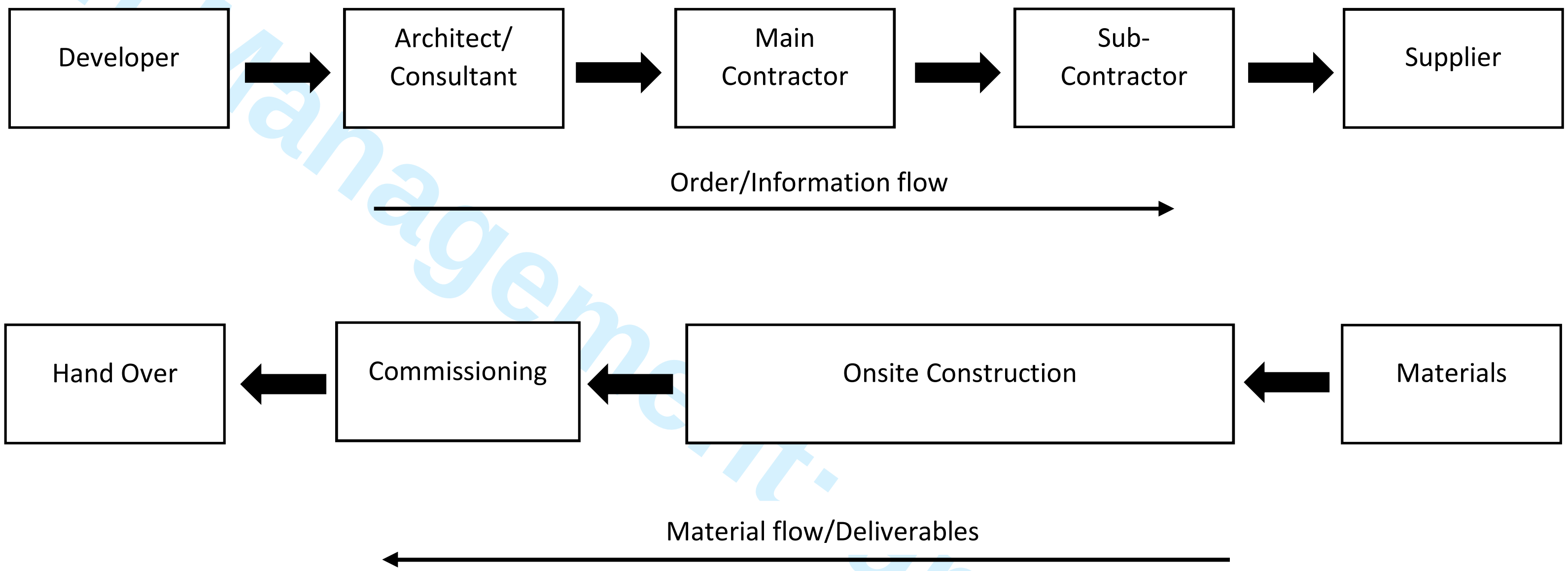

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Table I Measurement items of GSCM constructs for constructions sector

Constructs and Items	Stakeholder relevance				Literature Source (Construction and other sectors)
	D	AC	C	S	
Core green practices					
Green design					
Environmental impact assessment of design (GRDSGN1)	✓	✓			Ng et al. (2012); Zhang et al. (2011)
Provision for natural ventilation (GRDSGN2)	✓	✓			Ng et al. (2012); Zhang et al. (2011); Lui et al. (2012)
Provision for natural lighting (GRDSGN3)	✓	✓			Ng et al. (2012); Zhang et al. (2011); Lui et al. (2012)
Provision for waste water recycling (GRDSGN4)	✓	✓			Zhang et al. (2011); Lui et al. (2012)
Integration of photovoltaic panels (GRDSGN5)	✓	✓			Ng et al. (2012); Zhang et al. (2011)
Consideration for energy efficient lighting system (GRDSGN6)	✓	✓			Ng et al. (2012); Zhang et al. (2011)
Consideration for energy efficient heating and air conditioning (HVAC) systems (GRDSGN7)	✓	✓			Ng et al. (2012); Zhang et al. (2011)
Provision for the use of prefabricated components (GRDSGN8)	✓	✓			Ng et al. (2012); Zhang et al. (2011)
Consideration of materials with high recycled content and low embodied energy (GRDSGN9)	✓	✓		✓	Liu et al. (2012); Zhang et al. (2011); Ng et al. (2012)
Consideration to reduce the use of hazardous materials (GRDSGN10)	✓	✓		✓	Liu et al. (2012); Zhang et al. (2011)
Green purchasing					
Environmental criteria(s) are included in material purchase decisions (GRPURC1)	✓		✓	✓	Ofori (2000); Adetunji et al. (2008)
Environmental criteria(s) are included in tendering (GRPURC2)	✓		✓	✓	Varnas et al. (2009); Adetunji et al. (2008)
Green transportation					
Provision of accommodation to employees near project sites (GRTRAN1)	✓	✓	✓		BRE (2003)
Use of video conferencing (GRTRAN2)	✓	✓	✓	✓	TemaNord (2010)
Employees are encouraged to use shared transport and public transport (GRTRAN3)	✓	✓	✓	✓	BRE (2003)
Materials are transported in full truckload quantities (GRTRAN4)			✓	✓	BRE (2003); Ng et al. (2012)
Materials are transported in fuel efficient vehicles (GRTRAN5)			✓	✓	BRE (2003); Ng et al. (2012)
Green construction/green manufacturing					
Provision for waste water recycling at project/manufacturing site (GRNCON1)/(GRNMAN1*)			✓	✓	Zhang et al. (2011); Shrestha (2016)
Use of prefabricated components in projects (GRNCON2)			✓		Jaillon et al. (2009); Zhang et al. (2011)
Use of materials with high recycled content and low embodied energy (GRNCON3)			✓		Shrestha (2016)
Reducing use of hazardous materials (GRNCON4)			✓		Shrestha (2016)
Comprehensive waste management plan for project/manufacturing sites (GRNCON5)/ GRNMAN2*)			✓	✓	Shen and Tam (2002); Zhang et al. (2011)
Automation is used for onsite construction/manufacturing activities (GRNCON6) GRNMAN3*)			✓	✓	Jaillon et al. (2009); Chen et al. (2010)
Fuel efficient equipment/machinery are used at project/manufacturing site (GRNCON7) GRNMAN4*)			✓	✓	Shen and Tam (2002); Shi et al. (2013)
End of life management					
Environmental impact assessment during end-of-life demolition of projects (ENDMGT1)			✓		Ofori (2000); Ng et al. (2012)
Material from the end of life demolished projects is recycled (ENDMGT2)			✓		Ofori (2000); Ng et al. (2012)

**Corresponding items for Suppliers; '✓' indicates relevance of the items for the corresponding stakeholder; underlined text represents empirical studies in other sectors that have used similar items*
D-Developer; AC- Architect/Consultant; C-Contractor; S-Supplier

Table I Continued

Constructs and Items	**Stakeholder relevance**				**Literature Source (Construction and other sectors)**
	D	**AC**	**C**	**S**	
Facilitating green practices					
EMS & ISO Certification (FCLTGP1)	✓	✓	✓	✓	Adetunji et al. (2008); Zhu et al. (2007) (Automotive sector); Green et al. (2012) (Manufacturing sector)
Environmental training (FCLTGP2)	✓	✓	✓	✓	Shen and Tam (2002); Adetunji et al. (2008); Carris et al. (2012); Rao (2004) (ISO certified companies)
Environmental auditing (FCLTGP3)	✓	✓	✓	✓	Adetunji et al. (2008); Carris et al. (2012); Zhu et al. (2007) (Automotive sector); Green et al. (2012) (Manufacturing sector)
Cross-functional integration for greening (FCLTGP4)	✓	✓	✓	✓	Adetunji et al. (2008); Zhu et al. (2007) (Automotive sector); Green et al. (2012) (Manufacturing sector)
Green related research and development (FCLTGP5)	✓	✓	✓	✓	Adetunji et al. (2008); Carris et al. (2012); Vachon (2013) (Generic)
External drivers					
Government green-related regulations (EXTDRV1)	✓	✓	✓	✓	Ofori et al. (2000); Ofori et al. (2002); Pitt et al. (2009); Qi et al. (2010); Carris et al. (2012); Akadiri and Fadiya (2013); Hsu et al. (2013) (ISO 14001 companies); Zhu et al. (2005) (Diverse sectors); Lee (2008) (SME)
Pressure from supply chain stakeholders (EXTDRV2)	✓	✓	✓	✓	Ofori et al. (2000); Ofori et al. (2002); Adetunji et al. (2008); Pitt et al. (2009); Qi et al. (2010); Carris et al. (2012); Akadiri and Fadiya (2013); Zhu et al. (2005) (Diverse sectors)
Pressure from competitors (EXTDRV3)	✓	✓	✓	✓	Ofori et al. (2000); Ofori et al. (2002); Hsu et al. (2013) (ISO 14001 companies) Zhu et al. (2005) (Diverse sectors)
Pressure from end-consumers (EXTDRV4)	✓				Ofori et al. (2000); Ofori et al. (2002); Carris et al. (2012); Hsu et al. (2013) (ISO 14001 companies) Zhu et al. (2005) (Diverse sectors); Lee (2008) (SME)
Internal drivers					
Environmental Commitment (INTDRV1)	✓	✓	✓	✓	Ofori et al. (2000); Adetunji et al. (2008); Qi et al. (2010); Carris et al. (2012); Akadiri and Fadiya (2013); Hsu et al. (2013) (ISO 14001 companies); Zhu et al. (2005) (Diverse sectors)
Enhance reputation/brand image (INTDRV2)	✓	✓	✓	✓	Ofori et al. (2000); Ofori et al. (2002); Adetunji et al. (2008); Liu et al. (2012); Carris et al. (2012); Ben Brik et al. (2013) (Diverse sectors)
Reduce costs (INTDRV3)	✓		✓	✓	Ofori et al. (2000); Ofori et al. (2002); Pitt et al. (2009); Carris et al. (2012); Zhu et al. (2005) (Diverse sectors)
Enter foreign markets (INTDRV4)	✓	✓	✓	✓	DBIS (2013); Zhu et al. (2005) (Diverse sectors)
External barriers					
Shortage of green professionals (EXTBAR1)	✓	✓	✓	✓	Ofori (2000); Ofori et al. (2002); Zutshi and Creed (2014); Lui et al. (2012); Mathiyazhagan et al. (2013) (SME); Luthra et al. (2011) (automotive sector)
Shortage of green suppliers (EXTBAR2)	✓	✓	✓	✓	Shi et al. (2013); Luthra et al. (2011) (automotive sector)
Tight and inflexible stakeholder deadlines (EXTBAR3)	✓	✓	✓	✓	Sourani and Sohail (2011)
Lack of stakeholder engagement/collaboration (EXTBAR4)	✓	✓	✓	✓	Sourani and Sohail (2010); Zhang et al. (2011); Zutshi and Creed (2014); Lui et al. (2011); Carris et al. (2012); Mathiyazhagan et al. (2013) (SME)
Internal barriers					
High cost of implementation (INTBAR1)	✓	✓	✓	✓	Ofori et al. (2000); Ofori et al. (2002); Adetunji et al. (2008); Jaillon et al. (2009); Pitt et al. (2009); Sourani and Sohail (2010); Zhang et al. (2011); Carris et al. (2012); Shi et al. (2013); Zutshi and Creed (2014); Lui et al. (2011); Mathiyazhagan et al. (2013) (SME); Luthra et al. (2011) (automotive sector)
Lack of knowledge and awareness INTBAR2)	✓	✓	✓	✓	Ofori (2000); Jaillon et al. (2009); Pitt et al. (2009); Sourani and Sohail (2010); Zhang et al. (2011); Carris et al. (2012); Shi et al. (2013); Lui et al. (2012); Mathiyazhagan et al. (2013) (SME)

**Corresponding items for Suppliers; '✓' indicates relevance of the items for the corresponding stakeholder; underlined text represents empirical studies in other sectors that have used similar items*
D-Developer; AC- Architect/Consultant; C-Contractor; S-Supplier

Table I Continued

Constructs and Items	**Stakeholder relevance**				**Literature Source (Construction and other sectors)**
	D	**AC**	**C**	**S**	
Environmental performance measures					
Number of environmental accidents has declined (ENVPER1)	✓	✓	✓	✓	Gangolells et al. (2009); Zhu et al. (2005) (Diverse sectors); Zhu et al. (2007) (Automotive sector); Green et al. (2012) (Manufacturing sector)
Greenhouse gas emissions have decreased (ENVPER2)	✓	✓	✓	✓	Fernández-Sánchez and Rodríguez-López (2010); Chen et al. (2010); Adetunji et al. (2008); Gangolells et al. (2009); Zhu et al. (2005) (Diverse sectors); Zhu et al. (2007) (Automotive sector); Green et al. (2012) (Manufacturing sector); Varsei et al. (2012) (Generic)
Water consumption has decreased (ENVPER3)	✓	✓	✓	✓	Fernández-Sánchez and Rodríguez-López (2010); Chen et al. (2010); Tam et al. (2006); Gangolells et al. (2009); Zhu et al. (2005) (Diverse sectors); Zhu et al. (2007) (Automotive sector);
Energy consumption has decreased (ENVPER4)	✓	✓	✓	✓	Fernández-Sánchez and Rodríguez-López (2010); Chen et al. (2010); Tam et al. (2006); Adetunji et al. (2008); Gangolells et al. (2009); Sarkis (2006) (Small manufacturing sector); Varsei et al. (2012) (Generic)
Landfill waste has decreased (ENVPER5)	✓	✓	✓	✓	Fernández-Sánchez and Rodríguez-López (2010); Chen et al. (2010); Liu et al. (2011); Adetunji et al. (2008); Gangolells et al. (2009); Zhu et al. (2005) (Diverse sectors); Zhu et al. (2007) (Automotive sector); Green et al. (2012) (Manufacturing sector); Varsei et al. (2012) (Generic)
Material use has decreased (ENVPER6)	✓	✓	✓	✓	Fernández-Sánchez and Rodríguez-López (2010); Tam et al. (2006); Chen et al. (2010); Gangolells et al. (2009); Jaillon et al. (2009); Hervani et al. (2005) (Generic)
Hazardous material use has decreased (ENVPER7)	✓	✓	✓	✓	Fernández-Sánchez and Rodríguez-López (2010); Zutshi and Creed (2014); Zhu et al. (2005) (Diverse sectors); Zhu et al. (2007) (Automotive sector); Green et al. (2012) (Manufacturing sector)
Economic performance measures					
Material expenses per unit constructed/manufactured has decreased (ECONPR1)	✓		✓	✓	Chen et al. (2010); Gangolells et al. (2009); Zhu et al. (2005) (Diverse sectors); Zhu et al. (2007) (Automotive sector); Green et al. (2012) (Manufacturing sector)
Water expenses per unit constructed/manufactured has decreased (ECONPR2)	✓		✓	✓	Gangolells et al. (2009); Zhang et al. (2012);
Energy expenses per unit constructed/manufactured has decreased (ECONPR3)	✓		✓	✓	Chen et al. (2010); Zutshi and Creed (2014); Zhu et al. (2005) (Diverse sectors); Zhu et al. (2007) (Automotive sector); Green et al. (2012) (Manufacturing sector)
Cost of managing waste per unit constructed/manufactured has decreased (ECONPR4)	✓		✓	✓	Chen et al. (2010); Zhang et al. (2012); Zutshi and Creed (2014); Zhu et al. (2005) (Diverse sectors); Zhu et al. (2007) (Automotive sector); Green et al. (2012) (Manufacturing sector)
Total environmental penalties and fines per unit constructed/ manufactured has decreased (ECONPR5)	✓		✓	✓	Shen and Tam (2002); Zutshi and Creed (2014); Zhu et al. (2005) (Diverse sectors); Zhu et al. (2007) (Automotive sector); Green et al. (2012) (Manufacturing sector)
Organizational performance measures					
Increase in sales (ORGPER1)	✓	✓	✓	✓	Green et al. (2012) (manufacturing sector); Rao and Holt (2005); Ortas et al. (2014 (Diverse sectors)
Increase in sales price (ORGPER2)	✓	✓	✓	✓	Green et al. (2012) (manufacturing sector); Rao and Holt (2005); Ortas et al. (2014 (Diverse sectors)
Increase in market share (ORGPER3)	✓	✓	✓	✓	Green et al. (2012) (manufacturing sector); Rao and Holt (2005); Ortas et al. (2014 (Diverse sectors)
Increase in return on investment (ORGPER4)	✓	✓	✓	✓	Green et al. (2012) (manufacturing sector); Rao and Holt (2005); Ortas et al. (2014 (Diverse sectors)
Increase in profits (ORGPER5)	✓	✓	✓	✓	Green et al. (2012) (manufacturing sector); Rao and Holt (2005); Ortas et al. (2014 (Diverse sectors)

**Corresponding items for Suppliers; '✓' indicates relevance of the items for the corresponding stakeholder; underlined text represents empirical studies in other sectors that have used similar items*
D-Developer; AC- Architect/Consultant; C-Contractor; S-Supplier

Figure II Proposed green supply chain management framework for the construction sector

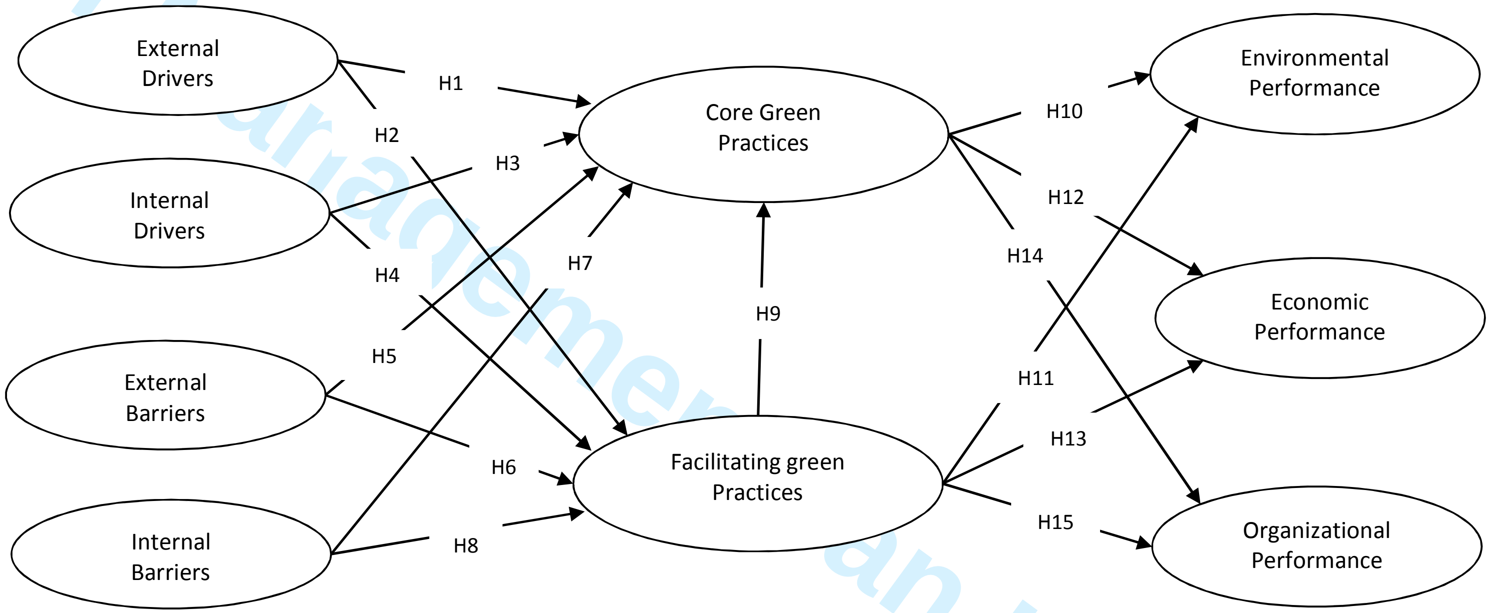

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Table II Classification of survey respondents

	Responses	Percentage
Stakeholder		
Developer	60	13.2%
Architect/Consultant	105	23.1%
Contractor	213	46.8%
Suppliers	77	16.9%
Total	**455**	**100%**
Size (employees)		
SME	216	47.5%
Large	239	52.5%
Total	**455**	**100%**
Firm ownership		
Local	189	41.5%
Foreign	266	48.5%
Total	**455**	**100%**
Respondents experience (in year)		
0-2	9	1.9%
3-5	69	15.2%
6-10	143	31.4%
>10	234	51.4%
Total	**455**	**100.0%**

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Table III Factor loadings of constructs (Developer, Architect/Consultant, Contractor, Supplier)

Item	Developer	Architect/Consultant	Contractor	Supplier
External Drivers				
EXTDRV1	0.88	0.87	0.76	0.21
EXTDRV2	0.75	0.81	0.84	0.97
EXTDRV3	0.86	0.91	0.86	0.94
EXTDRV4	0.42	-	-	-
Internal drivers				
INTDRV1	0.62	0.86	0.90	0.72
INTDRV2	0.60	0.89	0.92	0.85
INTDRV3	0.93	0.85	0.88	0.22
INTDRV4	0.70	0.89	0.89	0.69
External barriers				
EXTBAR1	0.56	0.80	0.80	0.81
EXTBAR2	0.42	0.70	0.80	0.52
EXTBAR3	0.87	0.71	0.71	0.93
EXTBAR4	0.72	0.79	0.81	0.86
Internal barriers				
INTBAR1	0.86	0.54	0.84	0.52
INTBAR2	0.86	0.84	0.77	0.90
Facilitating green practices				
FCLTGP1	0.83	0.75	0.53	0.35
FCLTGP2	0.85	0.49	0.77	0.77
FCLTGP3	0.66	0.90	0.80	0.84
FCLTGP4	0.94	0.70	0.68	0.34
FCLTGP5	0.88	0.89	0.68	0.99
Green design				
GRDSGN1	0.45	0.80	-	-
GRDSGN2	0.29	0.66	-	-
GRDSGN3	0.57	0.80	-	-
GRDSGN4	0.48	0.66	-	-
GRDSGN5	0.84	0.82	-	-
GRDSGN6	0.83	0.70	-	-
GRDSGN7	0.78	0.76	-	-
GRDSGN8	0.91	0.60	-	-
GRDSGN9	0.79	0.88	-	0.78
GRDSGN10	0.39	0.69	-	0.79
Green purchasing				
GRPURC1	0.95	-	0.94	0.82
GRPURC2	0.92	-	0.97	0.82
Green transportation				
GRTRAN1	0.96	0.80	0.82	-
GRTRAN2	0.92	0.90	0.85	0.24
GRTRAN3	0.89	0.87	0.85	0.98
GRTRAN4	-	-	0.83	0.87
GRTRAN5	-	-	0.88	0.94
Green construction/manufacturing				
GRNCON1/GRNMAN1*	-	-	0.67	0.95
GRNCON2	-	-	0.73	-
GRNCON3	-	-	0.84	-
GRNCON4	-	-	0.74	-
GRNCON5/GRNMAN2*	-	-	0.80	0.83
GRNCON6/GRNMAN3*	-	-	0.79	0.65
GRNCON7/GRNMAN4*	-	-	0.79	0.95
End of life management				
ENDMGT1	0.99	0.88	0.87	-
ENDMGT2	0.97	0.93	0.80	-
Environmental performance				
ENVPER1	0.68	0.75	0.62	0.91
ENVPER2	0.93	0.89	0.69	0.86
ENVPER3	0.68	0.84	0.76	0.87
ENVPER4	0.74	0.83	0.77	0.94
ENVPER5	0.96	0.85	0.77	0.75
ENVPER6	0.91	0.73	0.60	0.70
ENVPER7	0.64	0.79	0.66	0.87
Economic performance				
ECOPER1	0.77	-	0.79	0.67
ECOPER2	-	-	0.90	0.53
ECOPER3	-	-	0.92	0.72
ECOPER4	-	-	0.87	0.98
ECOPER5	0.82	-	0.70	0.94
Organizational performance				
ORGPER1	0.92	0.82	0.83	0.77
ORGPER2	0.83	0.85	0.81	0.69
ORGPER3	0.89	0.83	0.93	0.84
ORGPER4	0.97	0.81	0.91	0.90
ORGPER5	0.77	0.86	0.85	0.80

Corresponding items for Suppliers;

Underlined values represent items with factor loading less than 0.5;

'– ' indicates factor loadings are not applicable, as the item itself are not relevant for the corresponding stakeholder

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Table IV Descriptive Statistics

	Developer	Architect/Consultant	Contractor	Supplier
	Construct Mean (SD)	**Construct Mean (SD)**	**Construct Mean (SD)**	**Construct Mean (SD)**
External drivers	2.81 (1.13)	3.08 (0.93)	3.17 (1.16)	2.92 (0.69)
Internal drivers	2.61 (1.39)	3.56 (1.07)	3.52 (1.23)	4.29 (0.65)
External barriers	2.94 (0.84)	3.18 (1.07)	3.43 (1.02)	2.96 (0.91)
Internal barriers	3.59 (0.83)	3.16 (0.98)	3.55 (0.87)	3.66 (0.98)
Facilitating green practices	3.13 (1.30)	3.91 (0.87)	3.62 (0.90)	4.25 (0.58)
Green design	3.39 (1.21)	3.82 (1.06)	-	4.50 (0.73)
Green purchasing	3.28 (0.92)	-	3.77 (1.08)	4.14 (1.30)
Green transportation	2.85 (1.34)	3.37 (1.26)	3.63 (1.14)	3.95 (0.84)
Green construction /manufacturing	-	-	3.91 (0.97)	4.30 (0.63)
End of life management	2.63 (1.45)	3.34 (1.04)	3.70 (1.00)	-
Environmental performance	3.16 (1.05)	3.57 (1.07)	3.67 (.942)	4.29 (0.83)
Economic/cost performance	1.92 (1.07)	-	3.39 (1.03)	3.61 (0.97)
Organizational performance	2.84 (0.94)	3.41 (0.77)	3.25 (0.96)	3.32 (1.09)

Construct mean - Average of the individual mean values of the items representing that construct

Construct SD - Average of the individual standard deviation of the items representing that construct

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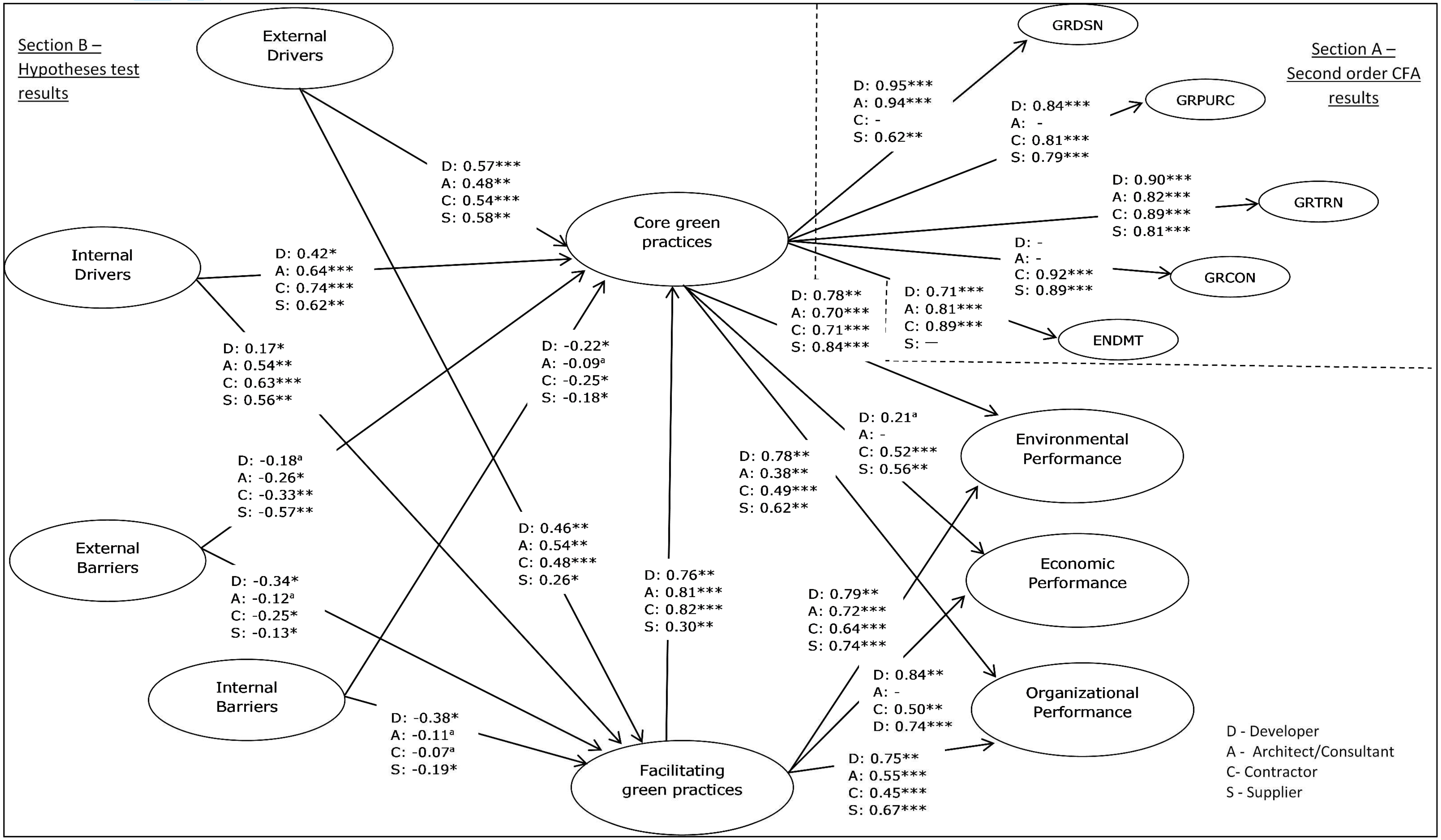
Figure III Second-order confirmatory factor analysis (CFA) and hypotheses test results



***significance at p<0.001; **significance at p<0.05; *significance at p<0.1; [a]not significant

Appendix I Mean values of individual items by stakeholder (scale 1-5)

Individual Items	Developer	Architect/ Consultant	Contractor	Supplier
Government green-related regulations (EXTDRV1)	3.33	2.11	3.71	a
Pressure from supply chain stakeholders (EXTDRV2)	1.89	4.03	3.01	3.00
Pressure from competitors (EXTDRV3)	3.22	3.09	2.80	2.83
Pressure from end-consumers (EXTDRV4)	a	-	-	-
Environmental Commitment (INTDRV1)	2.89	3.56	3.57	4.50
Enhance reputation/brand image (INTDRV2)	2.78	3.57	3.67	4.17
Reduce costs (INTDRV3)	1.98	-	3.50	a
Enter foreign markets (INTDRV4)	2.80	3.55	3.32	4.21
Shortage of green professionals (EXTBAR1)	3.44	2.71	3.21	2.91
Shortage of green suppliers (EXTBAR2)	a	3.11	3.26	3.33
Tight and inflexible stakeholder deadlines (EXTBAR3)	2.67	3.54	3.76	2.77
Lack of stakeholder collaboration (EXTBAR4)	2.70	3.37	3.49	2.83
High cost of implementation (INTBAR1)	3.62	3.45	3.73	4.33
Lack of knowledge and awareness of green practices (INTBAR2)	3.56	2.86	3.37	2.98
Environmental Management System and ISO Certification (FCLTGP1)	3.44	4.10	4.26	a
Environmental training (FCLTGP2)	3.11	a	3.96	4.50
Environmental auditing (FCLTGP3)	3.21	3.91	3.73	3.67
Cross-functional integration for greening (FCLTGP4)	3.33	4.26	3.77	a
Green related research and development (FCLTGP5)	2.56	3.37	2.39	4.57
Environmental impact assessment of design (GRDSGN1)	a	3.94	-	-
Provision for natural ventilation (GRDSGN2)	a	3.77	-	-
Provision for natural lighting (GRDSGN3)	4.02	4.05	-	-
Provision for waste water recycling (GRDSGN4)	a	3.89	-	-
Use of photovoltaic panels (GRDSGN5)	2.89	3.40	-	-
Use of energy efficient lighting system (GRDSGN6)	3.78	4.11	-	-
Use of energy efficient heating and air conditioning (HVAC) systems (GRDSGN7)	3.56	4.09	-	-
Use of prefabricated components (GRDSGN8)	3.22	3.69	-	-
Use of materials with high recycled content and low embodied energy (GRDSGN9)	2.89	3.41	-	4.51
Reducing use of hazardous materials (GRDSGN10)	a	3.83	-	4.49
Environmental criteria(s) are included in material purchase decisions (GRPURC1)	3.33	-	3.81	4.17
Environmental criteria(s) are included in tendering (GRPURC2)	3.22	-	3.72	4.11
Provision of accommodation to employees near project sites (GRTRAN1)	2.78	3.29	3.70	-
Use of video conferencing (GRTRAN2)	3.01	3.39	3.45	a
Employees are encouraged to use shared transport and public transport (GRTRAN3)	2.78	3.43	3.70	4.00
Materials are transported in full truckload quantities (GRTRAN4)	-	-	3.78	4.17
Materials are transported in fuel efficient vehicles (GRTRAN5)	-	-	3.52	3.67
Provision for waste water recycling at project/manufacturing site (GRNCON1) /GRNMAN1*	-	-	3.87	4.17
Use of prefabricated components in projects (GRNCON2)	-	-	4.04	
Use of materials with high recycled content and low embodied energy (GRNCON3)	-	-	3.81	
Reducing use of hazardous materials (GRNCON4)	-	-	4.17	
Comprehensive waste management plan for project/manufacturing sites (GRNCON5) /GRNMAN2*	-	-	3.93	4.33
Automation is used for onsite construction/manufacturing activities (GRNCON6) GRNMAN3*	-	-	3.86	4.41

a - indicates items that are excluded from the analysis for the corresponding stakeholder due to low factor loadings
‘ – ’ indicates mean scores are not applicable, as the item itself is not relevant for the corresponding stakeholder

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Appendix I Continued

Individual Items	Developer	Architect/ Consultant	Contractor	Supplier
Fuel efficient machinery are used at project/manufacturing site (GRNCON7) GRNMAN4*	-	-	3.69	4.29
Environmental impact assessment during end-of-life demolition of projects (ENDMGT1)	2.59	3.42	3.72	-
Material from the end of life demolished projects is recycled (ENDMGT2)	2.66	3.26	3.69	-
Number of environmental accidents has declined (ENVPER1)	3.23	3.45	3.87	4.67
Greenhouse gas emissions have decreased (ENVPER2)	3.11	3.57	3.56	4.17
Water consumption has decreased (ENVPER3)	3.19	3.74	3.56	4.33
Energy consumption has decreased (ENVPER4)	3.33	3.71	3.69	4.50
Landfill waste has decreased (ENVPER5)	3.13	3.54	3.56	4.01
Material use has decreased (ENVPER6)	2.78	3.17	3.50	4.03
Hazardous material use has decreased (ENVPER7)	3.36	3.81	3.92	4.33
Material expenses per unit constructed/manufactured has decreased (ECONPR1)	1.30	-	3.26	3.02
Water expenses per unit constructed/manufactured has decreased (ECONPR2)	-	-	3.39	3.67
Energy expenses per unit constructed/manufactured has decreased (ECONPR3)	-	-	3.42	3.83
Cost of managing waste per unit constructed/manufactured has decreased (ECONPR4)	-	-	3.37	3.89
Total environmental penalties and fines per unit constructed/ manufactured has decreased (ECONPR5)	2.54	-	3.50	3.66
Increase in sales (ORGPER1)	2.89	3.40	3.24	3.61
Increase in sales price (ORGPER2)	2.56	3.37	3.30	3.50
Increase in market share (ORGPER3)	2.87	3.51	3.27	3.50
Increase in return on investment (ORGPER4)	2.78	3.45	3.25	3.16
Increase in profits (ORGPER5)	3.11	3.31	3.17	2.83

a - indicates items that are excluded from the analysis for the corresponding stakeholder due to low factor loadings
'–' indicates mean scores are not applicable, as the item itself is not relevant for the corresponding stakeholder

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