

**Green Supply Chain Management: An investigation on the
construction sector**

by

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Appendix 4

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Abstract

Environmental pollution and climate change have become one of the greatest challenges of the 21st century, which have forced governments and businesses alike to assess the environmental impacts of their activities. Among the sectors, construction is the single largest contributor of global carbon emissions, resource, water and energy consumption, and landfill waste. With environmental implications expected to be even greater in the future due to increasing urbanisation and the consequent increase in construction activities, curtailing the negative environmental impacts of the sector or greening the construction sector, therefore, has become critical. Unfortunately, any limited efforts to date to address these concerns have been less fruitful as most of these efforts have been largely fragmented and disjoint, addressing issues in an ad-hoc, standalone manner such as green design, green purchasing, green construction or environmental management systems; or management issues such as 'drivers' and/or 'barriers' affecting these specific green practices; or specific performance implications from these green practices such as environmental and/or financial performance. This lack of holistic orientation also carries the risk that practitioners and policymakers could mistakenly be addressing the wrong issues and neglecting aspects that have more significance in greening the sector. Given the environmental consequences of a construction project are typically dispersed across the different stages in the supply chain, i.e. from design through to end-of-life, and that several stakeholders, each with their own conflicting interests, are involved in the different stages of the construction supply chain, greening the sector, therefore, requires a supply chain wide focus, inclusive of all key stages and stakeholders (Developers, Architects/Consultants, Contractors and Suppliers). Therefore, the application of green supply chain management (GSCM) or incorporating environmental concerns into supply chain management (a systematic and integrated approach) makes perfect sense for greening the construction sector. GSCM contributes to greening by promoting supply chain-wide implementation of efficient and effective green practices by means of managing the 'drivers' and 'barriers' affecting its implementation to achieve the desired environmental performance along with short-term economic/cost performance and long-term organisational performance.

This formed the focus of this study, wherein, it explores the application of GSCM in greening the construction sector. The study also explores the impact of firm size and ownership on GSCM, because, given the inherent complexity of the construction supply chain, i.e. it comprises of hundreds of firms with varying size and ownership, a comprehensive greening of the construction supply chain would not be possible without managing the impact of size and ownership on GSCM. Finally, given that GSCM understanding would be of limited value unless accompanied by general principles (theories) that inform wider application, the study utilises several established and emerging management/organisational theories to underpin the multifaceted reality of GSCM. In short, each of these GSCM aspects, i.e. green practices, green drivers and barriers, and green performance; and their interrelationships; and the impact of firm size and ownership on GSCM are investigated as separate research questions in this thesis. UAE is carefully chosen as the research setting for this GSCM study mainly because it gives an exemplary opportunity to understand the competing actions required from governments and construction sector firms to lessen the environmental impacts associated with the rapid urbanisation and economic modernisation. Specifically, on one side, the UAE construction sector is growing at more than 9%

per annum, while on the other side several green initiatives are considered by practitioners and policymakers to reduce its environmental burden on the country. Therefore, the related findings are expected to be more practically relevant to comprehend the challenges and opportunities in the application of GSCM.

A pragmatic, multi-methodology, sequential exploratory approach (i.e. the qualitative investigation followed by quantitative investigation) was employed to comprehensively answer the research questions. For the qualitative investigation, both semi-structured interviews (to explore and define each GSCM themes/sub-themes), and focussed, in-depth interviews (to gain operational/implementation level understanding) were employed. For the quantitative investigation, a structured country-wide survey was employed. The findings derived from the multiple methods (interviews and survey), were then combined to develop a comprehensive picture on the various facets of GSCM in relation to greening the construction sector.

With regard to the findings, the important/relevant core green practices (or environmental activities/initiatives undertaken across each of the distinct functional stages of the supply chain) identified for greening the construction sector include green design, green purchasing, green transportation, green construction/manufacturing and end of life green practices, whereas the important/relevant facilitating green practices (or activities/initiatives undertaken to build internal environmental resources and capabilities) identified for greening the construction sector include environmental management systems (EMS) and ISO 14001 certification, cross-functional integration, environmental auditing, environmental training and green-related research and development. The extent of implementation of these practices, in general, was found to be the highest among Suppliers, moderate among Architects/Consultants and Contractors, and lowest among Developers. The important/relevant external green drivers (external forces/pressures that coerce firms to implement green practices) identified include government green-related regulation, supply chain stakeholder pressure, competitor pressure and buyer/end-consumer pressure, whereas internal green drivers (internal forces/pressures that motivate firms to implement green practices) identified include environmental commitment of firms, enhance reputation/brand image, to reduce costs and to enter foreign markets. The relevance/importance perceived by stakeholders shows that all stakeholders except Developers are more motivated internally than externally to engage in green practices. On the other hand, the important/relevant external green barriers (external forces that hinder or restricts firms from implementing green practices) identified include shortage of green professionals, shortage of green suppliers, tight and inflexible stakeholder deadlines and lack of stakeholder collaboration, whereas internal green barriers identified include high cost of implementation and lack of knowledge and awareness. The relevance/importance perceived by stakeholders shows that Developers and Suppliers perceive internal barriers more than external, while Architects/Consultants and Contractors were found to perceive external and internal barriers to be more or less the same. The study also identified several important/relevant performance measures to capture environmental, economic/cost and organisational performance that firms could operationalise to capture the benefits of green practices. With regard to actual improvement in these performances, all three performances were found to be relatively lower for Developers, while moderate to high for other stakeholders.

With regard to the relationship between GSCM aspects, the extent of the impact of green drivers on green practices was found to far exceed the impact of green barriers on green practices, which self-explains the moderate extent of implementation of green practices across stakeholders. Moreover, it was found that both core and facilitating green practices have a significant and positive impact on three dimensions of performance across stakeholders, and the strength of impact, in general, ranged from moderate to high. Furthermore, facilitating green practices was found to have a strong and positive impact on core green practices. Finally, firm size and ownership was found to have a significant impact on the various GSCM aspects.

The study provides practitioners (across all stakeholders) with a potential stock of core and facilitating green practices that they could implement as well as potential performance measures they could operationalise in their respective firms. Also, it helps them to gauge the green drivers and barriers affecting their green practices implementation. The understanding of relationships such as the impact of green drivers and barriers on green practices is important for both policymakers (at the sector level) and practitioners (at the firm level) to devise strategies to effectively maximise/leverage the drivers and minimise/eliminate the barriers to promote efficient and effective green practices implementation. The positive impact of green practices on all three aspects of performance demonstrates the significant “win-win” opportunities that exist for stakeholders, and should therefore provide the impetus for firms to implement green practices. Also, practitioners could use this understanding to prioritise the implementation of those individual facilitating and/or core green practices that deliver the firm’s targeted green performance goals (taking all three performance aspects into consideration). Furthermore, the finding on the impact of facilitating green practices on core green practices shows that facilitating practices is a necessary precursor to the implementation of core green practices and therefore should provide the impetus for firms to make prioritised investment in facilitating practices to improve their core green practices. Also, the findings on the impact of size and ownership are important for all concerned parties to devise actions, strategies and policy interventions to ensure all firms, regardless of their size and ownership, contribute towards greening the sector. Overall, given that most of the underlying issues in construction are similar across countries, the insights from this study can be used as a good starting point for practitioners and policymakers elsewhere in greening the construction sector.

The study is arguably the first comprehensive attempt to understand GSCM and its importance/relevance in greening the construction sector. The study also provides several validated first-order constructs, namely external and internal drivers, external and internal barriers, facilitating green practices, environmental, economic/cost and organisational performance, and a second-order construct, core green practices, underlying the following first-order constructs: green design, green purchasing, green transportation, green construction/manufacturing and end of life green practices. This itself is a significant research contribution given that construct development and validation is at the heart of theory building. The study also provides a comprehensive GSCM framework underlying these constructs and their relationships. Future researchers could use/adapt this GSCM framework in their respective settings in construction or other sectors. Also, the application of several established/emerging theories to understand the various GSCM aspects has not been undertaken previously in the construction sector and hence constitutes a novelty.

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List of Abbreviations and Symbols

AGFI	Adjusted Goodness of fit index
AVE	Average Variance Extracted
CFA	Confirmatory factor analysis
CFC	Chlorofluorocarbon
CFI	Comparative fit index
CO ₂	Carbon-di-oxide
EMS	Environmental management systems
ESCM	Environmental supply chain management
FDI	Foreign direct investment
GFI	Goodness of fit index
GHG	Greenhouse gases
GSCM	Green supply chain management
HVAC	Heating, ventilation and air-conditioning
ISO	International Organization for Standardization
KBV	Knowledge-based-view
LEED	Leadership in Energy and Environmental Design
M	Mean or average
MD	Mean differences
NGO	Non-government organizations
p	Significance level
PA	Path Analysis
R&D	Research and development
RBV	Resource-based-view
RMSEA	The Root Mean Square Error of Approximation
SCEM	Supply chain environmental management
SD	Standard deviation
SEM	Structural equation modelling
SMFs	Small and medium firms
SSCM	Sustainable supply chain management
UAE	United Arab Emirates
UNEP	United Nations Environmental Program
\bar{X}	Arithmetic mean
α	Cronbach alpha
β	Standardized estimate
χ^2	Chi-square statistic

Chapter 1 - Introduction

This chapter provides the background and motivation of this research. It introduces the main research themes and specific objectives of the research. In addition, the setting in which the research will be carried out and its rationale is discussed. Finally, an outline of the structure of the thesis is presented.

1.1. Criticality of addressing environmental issues

Due to the mankind's pursuit of economic growth and industrial modernisation, the related issues of environmental pollution, climate change and resource depletion have become one of the greatest challenges of the 21st century (IPCC, 2007). The total global greenhouse gas (GHG) emissions, the main driver of climate change, amounted to approximately 52.7 gigatonnes of carbon dioxide equivalent (GtCO₂e) in 2014, the highest level reported since the pre-industrial levels (UNEP-EGR, 2014). Also, the increase in the annual rate of GHG emissions during the period 2000-2010 was faster (2.2%) than during the period 1970-2000 (1.3%) (UNEP-EGR, 2016). The effects of these emissions, mainly in the form of global warming and rising sea levels are clearly evident. For instance, 2015 was the hottest year recorded since modern record keeping and ten of the warmest years on record have occurred since 2000 (UNEP-EGR, 2016). Similarly, the rate of rising sea levels has accelerated in recent years (EPA, 2017).

The significant push for economic development and industrialisation is also amplifying the depletion of natural resources. At the current rates of use, the world will soon run out of many vital resources including renewable resources, as some of them need longer periods to be replenished. For example, assessment by the U.S. Energy Information Administration (EIA) shows that at the current rate of use, fossil fuels could be entirely depleted in the next 25 years (EIA-IEO, 2013).

The need for urgent action to address these concerns has bestowed increasing responsibility on governments and businesses alike to minimise the environmental impacts of their activities (IPCC, 2007). Though there have been efforts in the past to address these environmental issues such as green design or design for the environment (Dowie, 1994; Fiksel, 1996), green or

environmental conscious purchasing (Min and Galle, 1997), green manufacturing (Owen, 1993, Atlas and Florida, 1998), lean and re-manufacturing (Van der Laan et al., 1996; Florida, 1996), reverse logistics (Pohlen, and Farris, 1992; Kopicki, Legg, and Novak, 1993) and implementation of environmental management systems (Starkey, 1998), they have not been as effective as they could be because most of these green/environmental initiatives were undertaken in a “fragmented” and “disconnected” manner from each other (Carter and Rogers, 2008). Governments and organisations worldwide have now realised the need for more systematic and integrated approaches to tackling environmental problems.

1.2. A supply chain approach to greening or green supply chain management

Green supply chain management (GSCM), or incorporating environmental concerns into supply chain management (Srivastava, 2007), has emerged in recent years as a systematic and integrated approach to tackling the environmental concerns of various sectors such as general manufacturing, automobile, electrical and electronics (Malviya and Kant, 2015). This is because practitioners and policymakers have started to recognise that the life-cycle environmental impacts of product/project are dispersed across its supply chain stages from design to end of life (Hervani et al., 2005; Wu et al., 2011). The main goal of GSCM is to ensure efficient, effective and extensive implementation of ‘green practices’ or activities/initiatives to reduce the environmental footprint across the various supply chain stages (Awaysheh and Klassen, 2010; Perotti et al., 2012) by means of managing the ‘antecedents,’ i.e. drivers and barriers that affect the implementation of green practices (Walker et al., 2008; Drohomerecki et al., 2014; Luthra et al., 2015) to achieve the desired ‘performance outcomes’, i.e. environmental performance along with short-term and long-term financial performance (Rao and Holt, 2005; Green et al., 2012).

For seamless application of GSCM in any sector, it is important that these ‘green practices’ and associated ‘antecedents’ and ‘performance outcomes’ are managed at the level of individual stakeholders (in a sector) so that their conflicting interests can be balanced for a unified, sector-wide greening (Hervani et al., 2005; Gold et al., 2010; Drohomerecki et al., 2014). This is because the overall greening of a product/project is the sum total of complementary or at times overlapping efforts undertaken at the various supply chain stages (from the initial design to the end-of-life demolition) by relevant stakeholders, and laggardness of any stage or stakeholder

may adversely affect the overall greening efforts (UN-Global Compact, 2010). Furthermore, it is important to manage the impact/influence of firm characteristics such as size and ownership on the various aspects of GSCM (Zhu et al., 2008a; 2008b). This is because a typical supply chain will comprise several firms with varying sizes and ownership and overall greening of the supply chain is directly linked to the commitment and participation of all involved firms. Overall, the application of GSCM offers significant opportunities for curtailing the adverse environmental implications associated with any sector.

1.3. Green supply chain management in the construction sector

Among the various sectors, the construction sector has been identified as the one with the greatest potential to combat climate change and resource depletion (IPCC, 2007; Pinkse and Dommisse, 2009; GhaffarianHoseini et al., 2013). This is because 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 use (UNEP-SBCI, 2016). With growing urbanisation [approximately 70% of the world's population is expected to live in urban areas by 2050 (UN-DESA, 2014)] and the resulting increase in construction activities, environmental consequences can be expected to be even greater in the future. This is even more acute in developing countries/emerging economies, driven by the need to meet the growing demands of rising populations and growing middle classes (UNEP-SBCI, 2014). Hence, the need to combat/curtail the adverse environmental implications or greening the construction sector has become critical to ensure the survival of our future generations.

Like other sectors, the construction sector could also greatly benefit from the application of GSCM. This is because the environmental implications of a construction/building project (and consequently the sector) are spread across its supply chain (Ng et al., 2012). For instance, green practices, the central tenet of GSCM, can be applied to curb the environmental impacts associated with a wide range of activities in the construction supply chain, starting from the extraction of raw materials of building products to their manufacturing and distribution; building design, procurement, onsite construction, maintenance, renovation and end of life demolition (Hatmoko, 2008). Also, given the inherent complexity of the construction supply chain with

multiple stakeholders (Developers, Architects/Consultants, Contractors and Suppliers) involved at different supply chain stages of a project (Edum-Fotwe et al., 1999), with each having a reputation for low trust and adversarial relationships with others in the supply chain (Korczyński, 1996; Akintoye et al., 2000), the scope of GSCM seems even greater for the sector for managing its antecedents such as the conflicting interests and challenges of different stakeholders and in engaging them to implement green practices to the best of their abilities in a coherent manner vis-à-vis other supply chain stakeholders. Further, firms in the construction sector, which is known for its poor performance and low-profit margins (Agapiou et al., 1998, Yeo and Ning, 2002, Cox and Ireland, 2002), could use GSCM as a source of competitive advantage to achieve higher financial performance along with increased environmental performance. Besides, with a typical construction project comprising of hundreds, if not thousands of firms with varying size and ownership, GSCM is critical in ensuring the involvement and commitment of all firms in the supply chain.

Unfortunately, despite its potential, little is known regarding the application of GSCM in the construction sector. To date, no studies published on the construction sector have been able to conduct a comprehensive and systematic GSCM investigation covering the various supply chain stages and stakeholders. Any limited efforts so far by researchers and practitioners intended for the application of GSCM in the construction sector have been largely fragmented and disjointed, focussing on aspects mainly from an individual stakeholder's point of view such as the Developer (Abidin, 2010) or the Contractor (Qi et al., 2010), covering only a narrow range of GSCM issues, for instance, specific green practices such as green purchasing (Varnas et al., 2009), or antecedents of specific green practices such as drivers of green construction (Qi et al., 2010) or barriers to green purchasing (Sourani and Sohail, 2010), or specific performance outcomes such as environmental performance (Tam et al., 2006). The myopic nature of these investigations implies that the intertwined nature of the various supply chain stages and stakeholders, which are central to greening the construction sector, are not sufficiently captured and understood, and therefore run the risk that practitioners and policymakers could mistakenly be addressing the wrong issues and neglecting those that have more significance. Furthermore, only a limited number of studies have considered the impact of firm characteristics on GSCM aspects.

Therefore, the intrinsic differences in the green behaviour of different firms (in terms of size and ownership) in the supply chain are not sufficiently understood. Moreover, given the limited number of GSCM-related studies in the construction sector, many important aspects of GSCM such as green transportation, consumer influence on green practices and long-term organisational benefits of green practices on profits, market share and return on investment appear to have seen little or no investigation.

Lastly, none of the GSCM-related studies in the construction sector appears to have used established/emerging management/organisational theories to underpin their findings. For practitioners or policymakers faced with the reality of addressing complex sustainability challenges, the accumulation of empirical evidence is of limited value unless accompanied by general principles which might inform wider application (Carter and Rogers, 2008). Hence, it limits the generalizability and the transferability of the findings and frameworks developed for the construction sector in a country context to that of another, as well across different sectors (Touboulic and Walker, 2015).

1.4. Objectives of this research

The significance of GSCM in greening the construction sector coupled with the inherent gaps in the literature formed the motivation of this research, where a comprehensive, theory enabled GSCM investigation will be undertaken on the construction sector covering the implementation of various green practices across all key stages (from initial development of the design to end of life demolition and recycling), drivers for and barriers to their implementation (antecedents) and their different performance implications (outcomes), all at the level of individual stakeholders, i.e. Developers, Architects/Consultants, Contractors/Subcontractors and material Suppliers. The study will also investigate the influence of (stakeholder) firm size and ownership, so that any intrinsic differences can be understood and delineated. Also, the study will try to develop a higher-level abstraction of the GSCM concept in construction with the use of established/emerging management theories, depending on where and how these theories can, individually and in combination, contribute to providing a deeper, broader and more simplified conceptualization of GSCM perspectives. Given the scientific notion that sound theoretical principles are fundamental for decision-making and managerial actions as well as the

advancement of any field (Chen and Paulraj, 2004), the theoretical underpinnings of this study are expected to enhance the practical application of GSCM in the construction sector and in general, as well as contribute significantly towards further theoretical advancement of the field.

The specific objectives of this study are therefore as follows:

1. Comprehend the various GSCM aspects for the construction sector, namely green practices, drivers for and barriers to their implementation, and its impact on the environmental and financial performance (short-term and long-term) of firms across each supply chain stakeholder
2. Identify the important inter-relationships between these GSCM aspects critical for greening the construction sector
3. Understand the impact of firm size and ownership on the GSCM aspects
4. Offer multiple theoretical perspectives in realising the multifaceted reality of GSCM in the construction sector.

Overall, this comprehensive, theory enabled GSCM investigation and resulting insights are expected to provide practitioners and policymakers with an all-inclusive understanding of the various conditions necessary for greening the construction supply chain and consequently the sector.

1.5. Research setting

While the comprehensive GSCM investigation could be based anywhere, choosing a setting where construction intensity is high and green practice implementation has shown maturity can be expected to be more practically relevant to comprehend the challenges and opportunities in the application of GSCM in the construction sector.

The United Arab Emirates (UAE) has been experiencing an unprecedented construction boom in the last decade or so to meet the rising demands of its increasing population, growing at more than 9% per annum in the last few years (Zawya, 2014; 2015). The country's construction sector, which is home to some of the most innovative buildings, skyscrapers, and man-made islands, has in the process played a pivotal role in the growth and transformation of the UAE from a nomadic country to a modernised country. While this has placed a substantial environmental burden on

the country (around 75% of all the solid waste generated in UAE is from construction (SCAD, 2013)), including carbon emissions, simultaneously it has also triggered significant green practice implementation and propelled UAE to eighth in the world in terms of stock of LEED (or Leadership in Energy and Environmental Design) certified green buildings (LEED, 2015) and has managed to reduce its per capita carbon footprint (in metric tons) from 23 in 2008 to 20.4 in 2011, though UAE continues to be one of the highest per capita carbon emission countries (World Bank, 2016).

UAE is, therefore, an appropriate context for understanding the competing actions required from governments and organisations to lessen the environmental impacts associated with rapid urbanisation and economic modernization. Given that most of the underlying attributes of construction sectors are similar across countries, the lessons learned from this study can provide significant and novel insights on “greening” the sector for practitioners and policymakers elsewhere in the world, especially developing/emerging economies in a similar position, i.e. witnessing significant construction growth and facing associated environmental concerns.

1.6. Structure of the thesis

The thesis is organised into eleven chapters as shown in Figure 1.1.

Chapter 1 (this chapter) introduces the background and motivation of this research. The scope of this thesis including specific objectives is clearly stated.

In Chapter 2, a comprehensive and critical analysis of the literature is carried out in line with the research objectives to establish relevant and specific research questions. The chapter also reaffirms the background of and justification for this study.

Chapter 3 discusses in detail the philosophical stance of this thesis, the overall research process including the various methods used to conduct the research, their relevant explanation and justification within the broader context of alternative methods available. The chapter also assesses the validity and reliability of the data, constructs and factors considered in this study.

In Chapter 4, the findings related to the nature and extent of the implementation of relevant green practices undertaken by supply chain stakeholders is discussed, along with their implications.

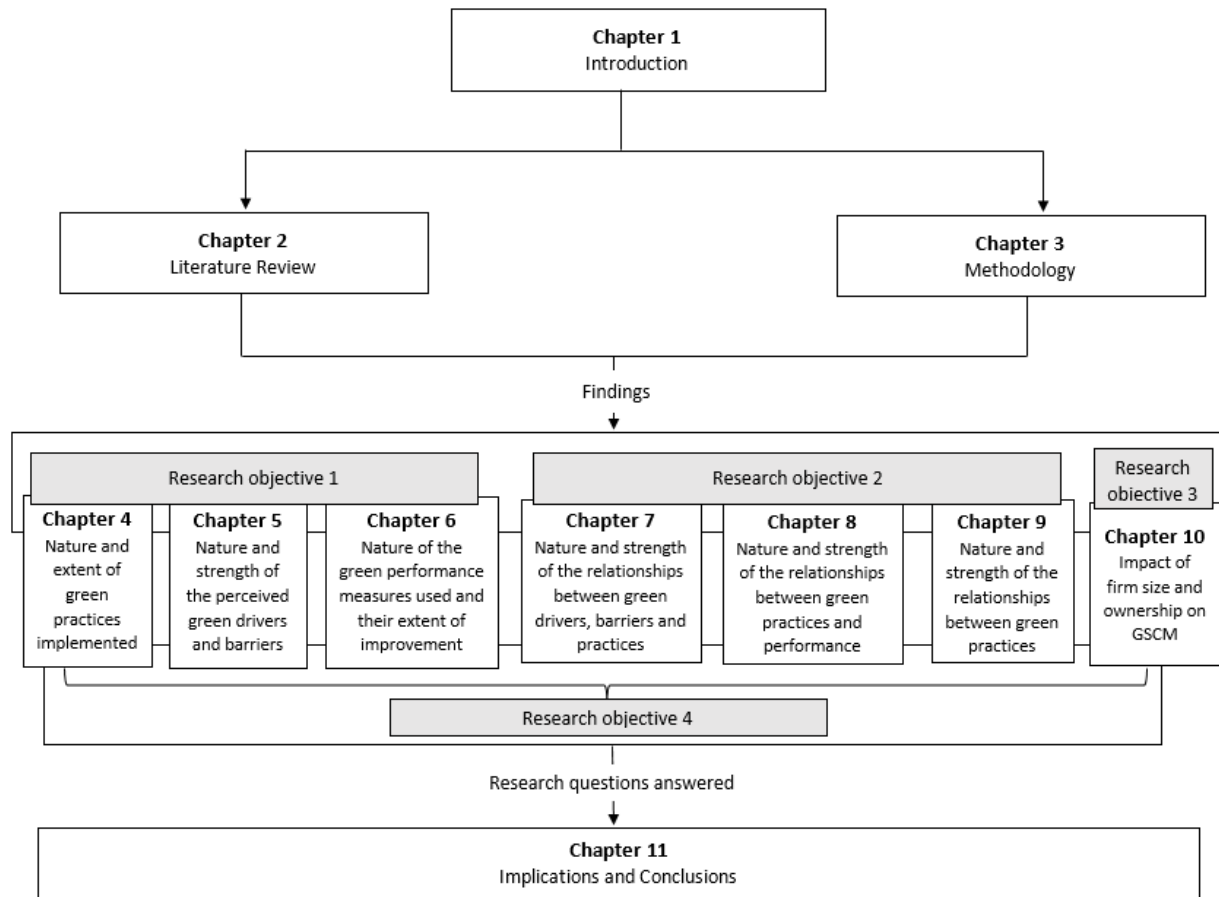


Figure 1.1 Overall thesis structure

In Chapter 5, the findings related to the nature and perceived importance/relevance of relevant green drivers and green barriers influencing each supply chain stakeholder are discussed along with their implications.

In Chapter 6, the findings related to the uses of green performance measures, namely environmental, cost/economic and organisational and their extent of improvement for each supply chain stakeholders are discussed along with their implications.

In Chapter 7, the findings related to the nature and strength of the relevant relationships between green drivers, green barriers and green practices for each supply chain stakeholder are discussed along with their implications.

In Chapter 8, all the findings related to the nature and strength of the relevant relationships between green practices and green performance for each supply stakeholder are discussed along with their implications.

In Chapter 9, all the findings related to the nature and strength of the relevant relationships between different green practices are discussed along with their implications.

In Chapter 10, all the findings related to the impact of firm size and ownership on the various GSCM aspects are discussed along with their implications.

The thesis concludes in Chapter 11, with the practical and research implications of the study along with its limitations and suggestions for future work.

In each chapter, several established/emerging management theories that offer a plausible basis to explain the findings are discussed.

Relevant publications from this work

Some of the main aspects of this thesis have been published in reputed International journals and conferences The full reference of these publications are as follows:

Journal Publications

1. Balasubramanian, S., Balasubramanian, S., Shukla, V., & Shukla, V. (2017). Green supply chain management: an empirical investigation on the construction sector. *Supply Chain Management: An International Journal*, 22(1), 58-81. (3* Journal)
2. Balasubramanian, S., & Shukla, V. (2017). Green supply chain management: the case of the construction sector in the United Arab Emirates (UAE). *Production Planning & Control*, 1-23 (3* Journal)

Conference Publications

1. Balasubramanian, S. & Shukla, V. (2014). Drivers, barriers and a framework for greening construction supply chains in the United Arab Emirates (UAE). *Proceedings of the 19th Annual Logistics Research Network Conference and PhD Workshop*, Huddersfield, UK, 3-5 September 2014
2. Balasubramanian, S. & Shukla, V. (2015). An empirical assessment of green supply chain management in the United Arab Emirates (UAE) construction sector. *Proceedings of the 20th Annual Logistics Research Network Conference and PhD Workshop*, University of Derby, UK, 9-11 September 2015
3. Balasubramanian, S. & Shukla, V. (2016). Theoretical Underpinning of Green Supply Chain Management in Construction. *Proceedings of the 21st Annual Logistics Research Network Conference and PhD Workshop*, University of Hull, UK, 7-9 September 2016

Chapter 2 – Literature Review

While the thesis introduced the broad aim of this research in Chapter 1, the goal of this chapter is to establish research questions by looking at what is already known/unknown in this area in terms of concepts, methods, inconsistencies/clashes of evidence, theories etc. through a comprehensive investigation and critical interpretation of the literature (Bryman, 2016). Since poorly formulated research questions will lead to poor research, this chapter is, therefore, important in formulating relevant, precise and demanding research questions. This chapter also reaffirms the background and justification for conducting this study and what its contribution is likely to be.

2.1. Green supply chain management – scope, definition, themes and theories

Before synthesising previous GSCM work in construction, it is important to define GSCM in terms of its scope and main themes. Traditional supply chain management (SCM) focused primarily on cost, quality and time with low regards to environmental consequences (Sarkis, 2003; Lu et al., 2007). The idea/concept of GSCM or integrating environmental concerns into supply chain management was first introduced in 1996 by the Manufacture Research Consortium (MRC) at Michigan State University (Baojuan, 2008). The objective was to develop a more systematic, effective and integrated approach to tackling environmental problems (Handfield et al., 1996; Walton, Handfield and Melynk, 1998, Beamon, 1999), a shift away from relying on several related but fragmented efforts to greening such as green/environmental design (Dowie, 1994; Fiksel, 1996), green/environmental purchasing (Min and Galle, 1997), green manufacturing (Owen, 1993, Florida, 1997), lean and re-manufacturing (Van der Laan, Salomon, and Dekker, 1996; Florida, 1996), reverse logistics (Pohlen, and Farris, 1992; Kopicki, Legg, and Novak, 1993) and environmental management systems (Court, 1996; Starkey, 1998).

Since then, the concept of GSCM has witnessed significant progress and application as evident from the growing number of publications in the domain (Ahi and Searcy, 2013). A longitudinal literature survey conducted by Malviya and Kant (2015) shows that that the number of articles published on GSCM has increased steadily from 1 article in 1998 to over 60 articles in 2012. However, the progress of GSCM has not only been in the number of publications but also in terms

of its maturation as a field of practice and as an academic domain. Starting from early conceptual developments introducing various concepts and practices related to GSCM, the field has matured through anecdotal case studies, theoretical development investigations, and theory testing empirical studies to more recent use of advanced modelling tools for evaluating GSCM (Seuring and Muller, 2008; Sarkis et al., 2011). The burgeoning interest in GSCM shows that governments and organisations worldwide are looking at ways to minimize/eliminate the environmental impacts of their activities, not just in their focal firm, but the entire supply chain as they have started to realize that the potential environmental impacts of a product/project are spread across the different functional stages - from design to end of life - of the supply chain (Hervani et al., 2005; Wu et al., 2011, Closs, Spier and Meachman, 2011).

2.1.1. Multiple perspectives of green supply chain management

Like supply chain management, the concept of GSCM has evolved dramatically with researchers looking at it from multiple perspectives. While this has broadened the scope and coverage of GSCM, it has also meant different terminologies and definitions of GSCM. For instance, a systematic review of the literature on the various definitions of GSCM by Ahi and Searcy (2013) has produced 22 unique definitions with no one complete definition to capture the scope of GSCM in its entirety. Table 2.1 shows some of the most cited GSCM definitions proposed by authors in chronological order. As seen in the table, these also include selected definitions from sustainable supply chain management (SSCM), environmental supply chain management (ESCM) and supply chain environmental management (SCEM). This is because these definitions are closely related to themes and concepts of GSCM to the extent that many researchers have used the terms interchangeably with GSCM (Ahi and Searcy, 2013). For example, SSCM can be considered as an extension of GSCM that includes additional social sustainability aspects (Ahi and Searcy, 2013). Throughout this section, the review has carefully considered relevant studies in SSCM, ESCM and SCEM by delineating and ignoring social and other aspects, which are beyond the scope of this thesis.

While the definitions were helpful in providing a peripheral understanding of the scope and the purpose of GSCM, a more in-depth content analysis of more than 100 articles in this domain enabled the conceptualisation of the key themes of GSCM.

Table 2.1 Definitions of GSCM

Source	Definition
Green et al. (1996)	Green supply refers to the way in which innovations in supply chain management and industrial purchasing may be considered in the context of the environment.
Handfield et al. (1997)	Application of environmental management principles to the entire set of activities across the whole customer order cycle, including design, procurement, manufacturing and assembly, packaging, logistics, and distribution
Seuring (2004)	The managerial integration of material and information flow throughout the supply chain to satisfy the demand of customers for green products and services produced by green processes
Zhu et al. (2005)	An important new archetype for enterprises to achieve profit and market share objectives by lowering their environmental risks and impacts while raising their ecological efficiency.
Sheu et al. (2005)	Combination of both the product manufacturing supply chain and used-product reverse logistics chain
Hervani et al. (2005)	Green Purchasing + Green Manufacturing/Materials Management + Green Distribution/Marketing + Reverse Logistics
Srivastava (2007)	Integrating environmental thinking into supply-chain management, including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumers as well as end-of-life management of the product after its useful life.
Seuring and Muller (2008)	The management of material, information and capital flows as well as cooperation among companies along the supply chain while taking goals from all three dimensions of sustainable development, i.e., economic, environmental and social, into account which are derived from customer and stakeholder requirements
Carter and Rogers (2008)	The strategic, transparent integration and achievement of an organisation's social, environmental, and economic goals in the systemic coordination of key inter-organisational business processes for improving the long-term economic performance of the individual company and its supply chains
Ahi and Searcy (2013)	The creation of coordinated supply chains through the voluntary integration of economic, environmental, and social considerations with key inter-organisational business systems designed to efficiently and effectively manage the material, information, and capital flows associated with the procurement, production, and distribution of products or services in order to meet stakeholder requirements and improve the profitability, competitiveness, and resilience of the organization over the short- and long-term.

**Sourced from Ahi and Searcy (2013) and Touboulic and Walker (2015)*

2.1.2. Key GSCM themes/sub-themes

Conceptualization of GSCM as theoretically and managerially relevant themes is important as it provides an integration and extension of all these different definitions and perspectives (Carter and Rogers, 2008). This is all the more important, given the lack of consensus on its definition and scope; otherwise, GSCM carries the risk of being considered as a discredited management fad comprising several standalone issues (Carter and Easton, 2011).

The main or central GSCM theme that emerged from this review is “green practices” (also referred to as GSCM practices) or activities/initiatives for improving the environmental performance along the supply chain. The two sub-themes identified within the main “green practices” theme are ‘core green practices’ (also referred to as external green practices) or practices undertaken to minimize the environmental footprint across each of the distinct functional stages of the supply chain, namely design, procurement, manufacturing and assembly, packaging, logistics, distribution, and reverse logistics/end of life management of a product after its useful life (Handfield et al., 1997; Hervani et al., 2005; Srivastava, 2007); and ‘facilitating green practices’ (also referred to as supporting or internal green practices) or practices undertaken at an intra-firm level to build internal resources and capabilities to achieve environmental goals such as implementation of environmental management systems (EMS) and ISO 14001 certification, cross-functional integration, environmental auditing and environmental training (Seuring and Muller, 2008; Zhu et al., 2012).

While these practices are useful for greening any sector, the adoption of these practices across firms or sectors has not been uniform. This has led researchers to contemplate why some firms or sectors implement a multitude of green practices more efficiently and effectively than others. Thus, researchers began investigating the “antecedents”, i.e., what drives or motivates firms to implement green practices? and what hinders or restricts firms from implementing green practices? (Seuring and Muller, 2008; Walker et al., 2008; Walker and Jones, 2012). This is important since the extent of green practices’ implementation would depend on the opposing pressures of drivers and barriers. The underlying basis for this is the force field theory (Lewin, 1951); higher the relative strength of drivers in comparison to barriers, more can be the expected green practice implementation (in depth and breadth terms) and vice versa. A comprehensive

understanding of these GSCM themes, namely “green drivers” and “green barriers”, would enable any sector to maximise green practices’ implementation by leveraging drivers and minimising/eliminating barriers. Several studies have further classified green drivers and barriers as ‘external’ and ‘internal’ green drivers and barriers as this give better manageability of antecedents based on their source of origin (Walker et al., 2008; Walker and Jones, 2012; Brik et al., 2013).

Here, external green drivers refer to forces/pressures that coerce firms to implement green practices that originate from outside the firm such as from governments, non-government organizations (NGO’s), competitors, other supply chain stakeholders and customers; whereas internal green drivers refer to forces/pressures that motivate firms to implement green practices that originate from within the firm (internally). This internal drive to implement green practices either arises from corporate responsibility/concern for the environment and/or to achieve clearly stated business benefits such as reducing cost, improving brand image and increasing market share (Seuring and Muller, 2008; Walker and Jones, 2012).

On the other hand, external barriers are impeding forces external to the firm that limit its ability to implement green practices such as shortage of green suppliers and shortage of green professionals; while internal barriers are impeding forces that originate from within the firm such as financial limitations restricting the ability to make the required investments in green practices and lack of skilled human resources with knowledge/experience of green practices (Walker and Jones, 2012). In short, ‘external green drivers’, ‘internal green drivers’, ‘external green barriers’, and ‘internal green barriers’ emerged as relevant GSCM sub-themes.

The other important theme of GSCM that emerged from this review is “green performance” or performance outcomes of green practices. While there is no questioning the fact that the *raison d’être* for implementing green practices is improving environmental performance, researchers have also linked green practices to financial performance, as both are important for justifying investment in green practices from a business perspective. The latter is important because many firms, even today, are still reluctant to implement green practices because they consider them to be an additional burden which requires high investments that lead to loss of competitive advantage (Giunipero et al., 2012). This reluctance is understandable, as the question of whether

green practices bring positive or negative financial performance remains debatable to date. The evidence in the literature is far from conclusive with some showing the direct and positive relationship between green practices and financial performance, while others show inconclusive or negative relationships (Zhu et al., 2007a; Laosirihongthong et al., 2013). The financial benefits from green practices' implementation can be further differentiated into short-term (referred to as cost/economic performance), which include aspects such as reduction in energy, water and material costs (Zhu et al., 2007a; 2007b; Green et al., 2012) and long-term financial performance - referred to as organisational performance - which include aspects such as increase in market share, profits and return on investments (Green et al., 2012; Lee et al., 2012). From a strategic perspective, this differentiation is important as firms invest in green practices either with a short-term focus and/or with a long-term focus. In brief, the three sub-themes within the main "green performance" theme are namely 'environmental performance', 'cost/economic performance', and 'organisational performance'.

To sum up, the main scope of GSCM can be conceptualized using these four key themes (or nine sub-themes), namely 1) green practices (core and facilitating); 2) green drivers (external and internal) 3) green barriers (external and internal); and 4) green performance (environmental, cost/economic and organisational). While it is acknowledged that the underlying aspects of themes/sub-themes could vary depending on the sector, the themes/sub-themes themselves are expected to hold good across sectors. This is further supported by the fact that studies in GSCM have started to apply extant and emergent theory, which helps in the advancement of GSCM as a cross-disciplinary field and helps in making meaningful generalisations and inter-sectorial transfer of knowledge (Touboulic and Walker, 2015). A comprehensive understanding of the various theories that have been applied or proposed in the GSCM context would be a good starting point towards developing a reliable theoretical basis for the GSCM in any sector including construction. In the next section, the existing studies in GSCM that have used/proposed established/emerging theories are reviewed.

2.1.3. Theoretical overview of green supply chain management

It is a widely regarded scientific notion that sound theoretical principles are fundamental to decision-making and managerial actions as well as to the advancement of any field (Chen and

Paulraj, 2004). Therefore, understanding the potential extant and emergent theories is important to relate GSCM to a larger body of knowledge and in providing a deeper, broader and more simplified conceptualization of its various aspects (themes/sub-themes).

This section provides an overview of several management and organisational theories from a variety of other fields and disciplines that have seen the application or perceived to be important in the nascent GSCM literature. Specifically, it critically engages with empirical studies in GSCM that have used one or more theoretical lenses to underpin their findings as well as reviewing studies such as Sarkis et al. (2011) and Touboulic and Walker (2015) that have solely focussed on proposing potential theories, especially with respect to our GSCM themes/sub-themes.

The objective is to identify and inherit theories presumed to be of relevance for better understanding GSCM in any sector, including construction. As expected, it was evident from the start that a small number of theories alone cannot capture the broad GSCM concept in its totality and that several theories are needed to explain the GSCM themes/sub-themes. For instance, each GSCM theme/sub-theme can be tied to various management/organisational theories. After a long and conscientious process of going through several theories and ensuring their compatibility and explanatory power vis-à-vis GSCM themes, a total of 13 management/organisational theories were identified from the literature including the few popular macroeconomic theories, namely resource-based & knowledge-based view, stakeholder theory, and institutional theory; and others, namely resource-dependence theory, diffusion of innovation theory, complexity theory, legitimacy theory, ecological modernization theory, social network theory, systems theory, transaction cost economics and agency theory to understand the GSCM concept. A brief outline of these management theories and their relevance to GSCM is provided in Table 2.2. At this point, it is presumed that these mentioned theories would be comprehensive enough to explain all the relevant findings of this thesis in the construction sector. If not, the thesis will further explore other potential theories including lesser known/emerging theories outside the realm of GSCM. The explanatory and predictive capability of the proposed theories is expected to enhance the practical application of GSCM in construction and in other sectors generally, as well as contribute significantly towards the theoretical advancement of the field.

Table 2.2 Relevant theories for GSCM

Theory	Description	Relevance to GSCM	Studies that suggested/applied these theories in GSCM/SCM
Agency theory (Eisenhardt, 1989)	Agency relationships occur when the principals hire the agent to perform a service on the principals' behalf. Principals commonly delegate decision-making authority to the agents	Tension can occur if there is a conflict in the environmental and economic goals of the principal and the agent. Also, it can occur in situations where agents often behave in ways that benefit them, not principals or vice versa	Sarkis et al. (2011); Touboulic and Walker (2015); Halldórsson et al. (2007; 2015)
Complexity theory (Prigogine and Stengers, 1984)	As complexity increases, firms may find it more and more difficult to plan and predict their organisational actions	In large supply chains, such as the construction supply chain, with many interacting parties, it may be difficult to manage and to ensure the green behaviours of the various supply chain entities are as expected. At an organisational level, implementation of green practices requires implementation of complex systems and policies and not all firms may be able to cope with the complexity.	Sarkis et al. (2011); Touboulic and Walker (2015)
Ecological modernization theory (EMT) (Spaargaren and Mol, 1992; Huber, 2000)	A systematic eco-innovation which includes technological innovation, policy innovation and organisational strategy geared towards achieving environmental improvements while maintaining economic gain.	GSCM can be considered an environmental innovation in achieving both environmental and economic performance (win-win situations). EMT can explain the varying level of green practices implementation among firms. For example, EMT-based GSCM studies explain how an environmental policies and regulations, both at the governmental level and firm level can promote/motivate firms to adopt GSCM.	Sarkis et al. (2011); Zhu et al. (2011)
Diffusion of innovation theory (Rogers, 2003)	Diffusion of innovation is the process by which an innovation is communicated through certain channels over time among the members of a social system.	Implementation of green practices can be considered as a relatively new and innovative practice and its extent of diffusion among stakeholders may vary depending on several factors	Sarkis et al. (2011); Zhu et al. (2012)

Table 2.2 Relevant theories for GSCM (continued)

Theory	Description	Relevance to GSCM	Studies that suggested/applied these theories in GSCM/SCM
Institutional theory (DiMaggio and Powell, 1983)	External pressures (coercive, mimetic and normative) can influence organisational actions	The theory can be used to explain why firms implement green practices as well as their extent of implementation.	Sarkis et al. (2011); Touboulic and Walker (2015); Lee et al. (2013); Hsu et al. (2013); Laosirihongthong et al. (2013); Zhu et al. (2013)
Legitimacy theory (Deegan, 2000; O'Donovan, 2002)	The theory can explain the behaviour of organisations in implementing and developing voluntary social and environmental disclosure of information	Achieving and capturing performance improvements resulting from the implementation of green practices can be used to gain legitimacy and recognition of a firm's green objectives	Touboulic and Walker (2015)
Resource-based and knowledge-based view (Barney, 1991; Grant 1996)	Competitive advantage may be sustained by harnessing resources including knowledge that is valuable, rare, imperfectly imitable, and non-substitutable	Sufficient intra-organisational resources are required for the implementation of green practices	Sarkis et al. (2011); Touboulic and Walker (2015); Carter and Rogers (2008); Halldórsson et al., (2007; 2015); Lee et al. (2013)
Resource-dependence theory (Pfeffer and Salancik, 1978).	In the supply chain, firms are dependent on resources provided by others to sustain growth, as well as other organisations that may be dependent on them	In GSCM, the effective implementation of green practices requires high dependence and collaboration with other stakeholders in the supply chain as most firms may not be fully self-sufficient with regards to the implementation of green practices.	Sarkis et al. (2011); Touboulic and Walker (2015); Carter and Rogers (2008); Lee et al. (2012)
Social network theory (SNT) (Granovetter, 1973)	SNT considers organisational outcomes as a function of the social relationships between firms or individuals in an organisation. An SNT has been described as having two major elements namely, density and centrality	It argues that the performance of a firm depends on the structure of the extended supply network. It can explain the role of dyadic stakeholder transactional and collaborative relationships in the supply chain in improving green practices and green performance. It can also explain the response of foreign firms and large firms to external pressures.	Sarkis et al. (2011); Tachizawa and Wong (2014); Touboulic and Walker (2015)

Table 2.2 Relevant theories for GSCM (continued)

Theory	Description	Relevance to GSCM	Studies that suggested/applied these theories in GSCM/SCM
Stakeholder theory (Freeman, 1984)	Firms do have the responsibility to ensure their activities meet the expectations of its various stakeholders, that are both internal and external to the firm	Stakeholder analysis for GSCM is important to understand whether stakeholders can harmonise their conflicting interest and implement green practices in a coherent manner with other stakeholders in the supply chain. It can also tell the extent of pressure exerted by one supply chain stakeholder on the other to implement green practices.	Sarkis et al. (2011); Touboulic and Walker (2015); Zhu et al. (2008c)
Systems theory (Checkland and Holwell, 1997)	It argues that the component part of a system can be best understood in the context of relationships with other systems rather than in isolation	Applying systems theory higher level abstraction of complex GSCM relationships	Caddy and Helou (2007); Tachizawa and Wong (2014); Touboulic and Walker (2015)
Transaction cost economics (Williamson, 1981)	Transaction cost economics focuses on how much effort and cost is required for two entities, buyer and seller, to complete an activity (economic exchange or transaction)	To assess the win-win opportunities for all parties involved in the achieving the desired environmental goals of the project.	Sarkis et al. (2011); Touboulic and Walker (2015); Carter and Rogers (2008); Halldórsson et al., (2007; 2015)

2.1.4. Sectorial gaps in green supply chain management application

Despite the significant progress and application of GSCM in the last decade, a major concern identified in this review is that the uptake of GSCM across various sectors has been uneven. The construction sector, which is the focus of this thesis, has seen only very limited application. For instance, a review of 177 GSCM related studies by Malviya and Kant (2015) shows that the focus of GSCM has been mainly in sectors such as automotive, general manufacturing, electronic and chemical industry. Table 2.3 shows the sectorial gaps in the GSCM literature reported by Malviya and Kant (2015). As seen in the table, the review could only relate one study in GSCM which has some relevance to the construction sector.

Table 2.3 Frequency of GSCM studies by sector

Industry	Frequency
Automotive industry	15
Manufacturing industries	14
Electronics industry	11
Chemical industry	7
Computer industry	5
Textile and apparel industry	5
Fashion industry	4
Logistics industry	4
Printing Industry	4
Apparel industry	2
Food and beverage industry	2
Hotel Industry	2
Semiconductor industry	2
Pulp and paper industry	2
Service industry	2
Mining industries	2
Construction industry	1

Source: Malviya and Kant (2015)

This lack of application of GSCM in the construction sector could be attributed to the inherent complexity of the sector and its supply chain (Vrijhoef, 1998; Hatmoko, 2008). Given the limited number of GSCM studies in construction, the scope of the review in this chapter will extend to include green/environmental studies in construction that have looked at isolated but related aspects of GSCM. These are referred to as GSCM-related studies. However, before conducting

the review, it is important to understand the intrinsic characteristics of the construction supply chain including the roles and responsibilities of its key stakeholders; the order/information flow in the supply chain; the materials/deliverables flow in the supply chain and the uniqueness/differences and similarities with other sectors such as manufacturing. This could reveal some of the potential challenges and opportunities in the application of GSCM in construction, which in turn could shape the focus of the review of GSCM-related studies in construction and in framing the research questions. The next section, therefore, discusses the inherent characteristics of the construction supply chain.

2.2. Construction supply chain – key stakeholders and features

Construction supply chains can be very complex, especially in large building projects. Figure 2.1 illustrates the construction supply chain in terms of its key stakeholders and their roles and responsibilities. It also shows how the order/information flow and material/deliverable flow take place in the supply chain.

2.2.1. Key stakeholders

As seen in figure 2.1, the key stakeholders in the construction supply chain are Developers, Architects/Consultants, Main Contractor, Subcontractor and Suppliers. The main roles and responsibilities of these stakeholders are as follows:

- *The Developer* is the one who initiates the project and therefore enjoys a hierarchical position with power in the supply chain to influence the whole project through its decisions on setting up the project and procurement system (Bresnen and Haslam, 1991). For this reason, Developers are considered to be the most important stakeholder in the construction supply chain (Briscoe et al., 2004). Therefore, their strategic decisions are vital for creating green supply chains, as their green building requirements will play a pivotal role in the green behaviour of other downstream supply chain stakeholders.
- *The Architects/Consultants* are typically responsible for the building design and 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 projects.

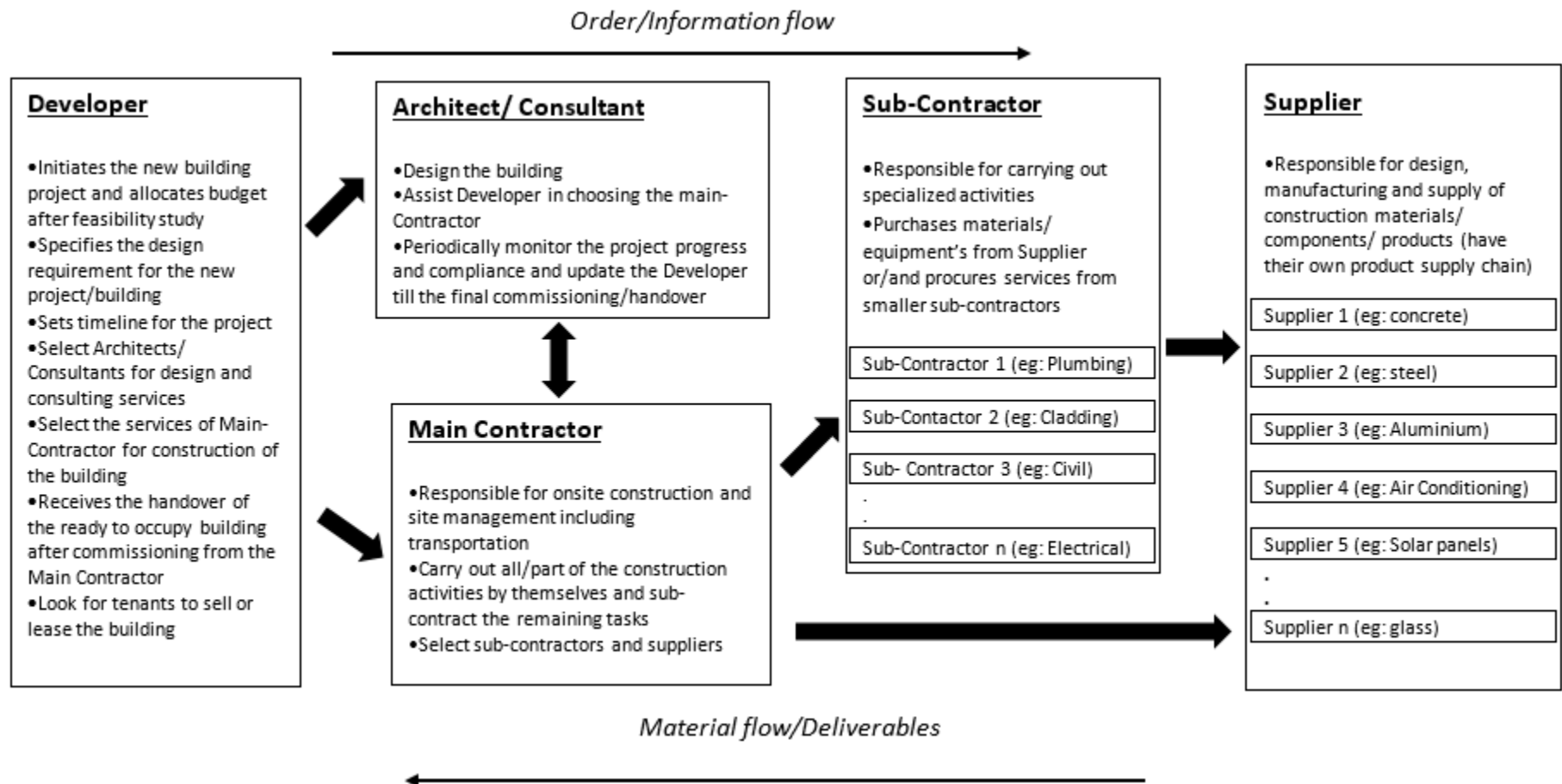


Figure 2.1 Construction supply chain

- *The main Contractors* are responsible for the completion of the project to a pre-determined time, cost and quality. Hence, they play a significant role in the project's success (Hatmoko, 2008). They typically play the role as a 'facilitator' to manage demand-side from the Developers/Architects and supply side from Subcontractors and Suppliers (Cox et al., 2006).
- *The Subcontractors*, too, play important roles in construction projects. They help the main contractor to carry out specialist works. It is not uncommon for as much as 90% of a construction project to be subcontracted (Matthews et al., 2000) and consequently, subcontractors may contribute as much as 90% of a main contractor's turnover (Ndekuri, 1998). This shows the important position and contribution of subcontractors in the success of the project.
- *The Suppliers* on the other hand supply materials or components for construction projects in time and at a reasonable cost (Venkataraman, 2004), which can reach a value of as much as 50-60% of the total cost of the project (Stuckhart, 1995). They contribute to the project success through shorter cycle time, inventory level reduction and improving service level (Venkataraman, 2004). For greening the construction supply chain, these aspects justify the importance of selecting and managing green suppliers in a construction project.

In summary, Developers, Architects/Consultants, main Contractors, Subcontractors and Suppliers have strategic positions in the supply chain and therefore are critical in creating green supply chains.

2.2.2. Order/information flows

In a typical construction supply chain, the Developer appoints Architects/Consultants based on suitable selection criteria to be their client representative, to supply both design and specialist management services. Once the building design is finalised, the Developer then finalises the tender documents with Architects/Consultants and floats the tender. The main Contractor is then selected by the Developer based on the technical (typically evaluated by the Architect/Consultant) and commercial proposal/bid (typically evaluated by Developer) submitted

by the Contractor. Once the main contractor is selected, based on their capabilities, they either carry out the construction activities themselves or hire specialist subcontractors to carry out specific activities such as the installation of the building façade, HVAC systems, building management systems (BMS). The complexity may further increase as Subcontractors may possibly subcontract their works, partly or wholly, to other subcontractors. Finally, both the main Contractor and the Subcontractors will have to rely on several Suppliers to provide them with raw materials and components to carry out their required activities.

2.2.3. Material flow/deliverables

In terms of material flow/deliverables, the raw materials such as cement, pre-fabricated components such as glass façade and systems such as HVAC are processed and assembled onsite by the main/sub-Contractors. Upon completion of the building, the final commissioning of the building will be executed by the 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. Overall, this information and material flow perspective of construction supply chain further demonstrates the need for commitment and involvement of all key supply chain stakeholders for the comprehensive greening of construction supply chains and shows that the laggardness of even a single stakeholder can adversely impact the overall greening efforts.

2.2.4. Key differences with other supply chains

For effective greening of the construction supply chain, it is important to understand the uniqueness and differences of construction supply chains vis-à-vis other supply chains. For instance, in contrast to the unilateral, long-term nature of the relationship between manufacturers and suppliers in typical manufacturing supply chains, construction supply chains are complex, diverse and fragmented and involve a multitude of stakeholders in dyadic, short-term/temporary relationships that last only until project completion (Rezgui and Miles, 2009). In a large construction project, for example, the number of organisations involved could be in hundreds, if not thousands. This means that for effective and extensive application of GSCM, each stakeholder needs to implement green practices to the best of their abilities in a coherent manner vis-à-vis others (Compact UN-Global, 2010). Moreover, the construction supply chain has

a reputation for low trust and adversarial relationships between stakeholders (Korczyński, 1996; Akintoye et al., 2000). Latham (1994) highlights the adversarial attitude between the main Contractors and their Suppliers in the case of the UK construction sector. Therefore, understanding and addressing the conflicting interests of each stakeholder potentially could improve their active participation in the greening efforts. Ghurka (2003) provide an interesting summary of the differences between a traditional or manufacturing supply chain and a construction supply chain, as shown in Table 2.4

Table 2.4 Comparison of manufacturing and construction supply chain

Traditional/manufacturing supply chain	Construction supply chain
Build to stock model is widely used	Build to order model is widely used
High degree of standardisation with repeatability	Each project has unique design and material specifications with little or no repeatability
Reliable demand forecast and planning can be done	Uncertain demand forecast and inadequate tools for planning
Generally, only one organisation is responsible for the production process	Multiple organisations with different objectives involved in the production process
Predefined supplier and distribution network	Project-specific suppliers and distribution network

Source: Ghurka (2003)

2.2.5. Potential similarities with other supply chains

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 are carefully crafted and contextualised (Harty 2008; Kumaraswamy et al. 2008). For instance, aspects such as “supply chain partnering” and “supply chain collaboration”, common in other sectors such as manufacturing, are now seen in the construction sector. For example, Developers have begun to enter into partnerships with key Contractors and these Contractors are exploring the possibilities of extending partnering/collaborative agreements down the supply chain to key material Suppliers and smaller Subcontractor firms (Tennant and Fernie, 2014). Moreover, the green behaviour of a construction material/product Supplier, a key member of the supply chain in greening the sector, who is responsible for the extraction and

processing of raw materials, manufacturing and distribution of construction material/products, would be comparable to that of any manufacturing sector.

Overall, the insights from this subsection, including the roles and responsibilities of key supply chain stakeholders, the material and information flow perspectives in the construction supply chain, and their differences and similarities with supply chains in other sectors, has helped to better frame the literature review and synthesis of limited and fragmented GSCM-related studies in construction (discussed in the next section) to comprehend the current status of GSCM in the construction sector including the relevant gaps in the literature. The next section, discusses the outcomes of the review of GSCM-related studies in the construction sector.

2.3. Previous GSCM-related work on construction sector

A comprehensive synthesis of the previous GSCM-related studies in the construction sector was carried out in conjunction with a larger body of GSCM literature in other sectors which have seen significant progress in the last decade or so (as discussed earlier) to help delineate the relevant GSCM gaps in the construction literature. Based on these pertinent gaps and their practical significance for greening the construction sector, several important research questions are proposed. Table 2.5 summarises the previous GSCM-related work on construction. It includes the most relevant articles, though the list may not be exhaustive. Studies which were considered to be either too generic or too technical were excluded. Nonetheless, the studies reviewed in Table 2.5 provide a realistic depiction of the current status of GSCM in the construction sector.

As seen in the table, each study is classified according to its country of investigation, the methodology used, primary focus, stakeholders involved and organisational characteristics. Importantly, the key findings of these studies are classified according to the main GSCM themes/sub-themes.

Now that the GSCM-related literature in construction has been identified and classified, each of the following sections now critically analyses the literature and discusses the pertinent gaps in GSCM in construction including the gaps in the GSCM themes and their relationships which are pivotal for greening the construction sector. This enables us to understand what is already known and importantly what needs to be known leading to the proposed research questions.

Table 2.5 Review of green literature on the construction sector

Study	Country	Methodology	Primary Focus	Stakeholder; and their Characteristics*	Key Findings
Ofori (2000)	Singapore	Literature review	Greening of the supply chain	-	Green purchasing practices: Purchase of recyclable products and those with non-toxic ingredients, supplier training on environmental practices, supplier implementation of environmental management systems incl. ISO 14000 and supplier environmental audit
Ofori et al. (2000) Ofori et al. (2002)	Singapore	Survey	Environmental management system (EMS) and ISO 14001	Developer, Consultant and Contractor	Drivers of EMS and ISO 14001: Mandatory government environmental requirements, client demands, non-government environmental group campaigns, reducing material wastage, enhancing company's public image, reducing costs and environment protection Barriers to EMS and ISO 14001: High implementation cost, recovery of related investments, lack of government support, lack of knowledge, shortage of qualified personnel
Shen and Tam (2002)	Hong Kong	Survey	Environmental management system (EMS)	Contractor	Drivers of EMS: Reduction in environment related fines and associated savings, improvement in corporate image, environment protection Barriers to EMS: Lack of government enforcement, increase in costs, lack of trained staff and expertise
Tam et al. (2006)	Hong Kong	Survey and interviews	Environmental performance	Developer, Consultant, Main/Sub-Contractor, Large, Medium and Small firms	Environmental performance measures: Reduction in energy, material and water consumption

*Blank means that specific stakeholders and their characteristics are not considered in those studies

Table 2.5 Review of green literature on the construction sector (continued)

Study	Country	Methodology	Primary Focus	Stakeholder; and their Characteristics*	Key Findings
Begum et al. (2007) Begum et al. (2009)	Malaysia	Survey	Waste management and minimization	Contractors	<p>Green purchasing practices: Purchase of durable and re-usable materials, and purchase of non-toxic materials</p> <p>Green construction practices: Use of low waste technology, onsite waste segregation, re-use and recycling of on-site construction waste.</p> <p>Environment training: Offering education and training programs</p>
Adetunji et al. (2008)	UK	Case study	Sustainability in supply chains	-	<p>Drivers of sustainable practices: Government regulations and associated fines, client requirements, top management commitment, reduction in total project costs, improvement in reputation and image, organisational vision on sustainability</p> <p>Barriers to sustainable practices: High implementation cost</p> <p>Sustainable practices: Implementation of EMS and ISO 14001, setting environment related pre-qualification criteria for suppliers, environmental training for in-house staff and suppliers, purchasing/using materials that cause less environmental damage and have higher recycled content</p> <p>Environmental benefits: Reduction in polluting emissions, environmental accidents and energy consumption, waste minimization, water conservation</p> <p>Economic benefits: Lower project costs</p>

*Blank means that specific stakeholders and their characteristics are not considered in those studies

Table 2.5 Review of green literature on the construction sector (continued)

Study	Country	Methodology	Primary Focus	Stakeholder; and their Characteristics*	Key Findings
Jaillon et al. (2009)	Hong Kong	Survey	Pre-fabrication	-	<p>Barriers to pre-fabrication: Higher cost per unit floor area in comparison to traditional approaches, lack of skilled labour</p> <p>Environmental benefits: Reduction in waste</p> <p>Economic benefits: Reduction in construction time and onsite labour requirement</p>
Pitt et al. (2009)	UK	Survey	Sustainable construction practices	Developer, Architect, Contractor	<p>Drivers of sustainable practices: Client demand, government regulations, financial benefits</p> <p>Barriers to sustainable practices: Lack of affordability, lack of awareness</p>
Robin and Poon (2009)	Hong Kong	Survey	Cultural shift in sustainability	Developer, Architect/Consultant, Contractor and Supplier	Cultural shift in sustainability in terms of awareness, concern, motivation and implementation
Varnas et al. (2009)	Sweden	Survey and interviews	Green purchasing	Developer	Green purchasing practices: Environmental criteria at the design stage, requirement to have an environmental and waste disposal plan, to use energy efficient onsite machinery and to use less environmentally harmful materials
Gangoellis et al. (2009)	Spain	Focus group and case study	Environmental impact measures	-	Environmental impact measures: Greenhouse gas emissions, water consumption, waste reduction, material consumption, energy consumption, environmental accidents

*Blank means that specific stakeholders and their characteristics are not considered in those studies

Table 2.5 Review of green literature on the construction sector (continued)

Study	Country	Methodology	Primary Focus	Stakeholder; and their Characteristics*	Key Findings
Chen et al. (2010)	US	Survey	Sustainability measures	Developer, Architect, Contractor, Supplier	Environmental performance measures: Reduction in air emissions, material consumption, energy consumption and water consumption, reduction in waste generated. Economic performance measures: Reduction in material and waste disposal costs
Abidin (2010)	Malaysia	Survey	Awareness about sustainable construction	Developer, Small, Medium and Large firms	Environmental aspects of sustainability: High awareness Economic aspects of sustainability: Low awareness
Fernández-Sánchez and Rodríguez-López (2010)	Spain	Literature review and case study	Sustainability indicators for construction	-	Environmental Indicators: Water consumption, air emission, material consumption, energy consumption and waste management Economic Indicators: Reduction in cost
Lam et al. (2010)	Hong Kong	Survey	Factors affecting implementation of green specification	Developer, Architect/Consultant, Main/Sub-Contractor and Suppliers	Five factors identified include green technology and techniques, reliability and quality of specification, leadership and responsibility, stakeholder involvement, guide and benchmarking systems
Qi et al. (2010)	China	Survey	Drivers of green practices in construction	Contractor, Small, Medium and Large firms	Drivers of green practices: Government environmental regulations, top management commitment, client pressure, pressure from environmental non-government organisations
Sourani and Sohail (2011)	UK	Interviews	Barriers to green purchasing in construction	-	Barriers to green purchasing: Lack of funding and high capital cost, lack of awareness and knowledge, lack of long-term partnership in the supply chain and lack of government incentives

*Blank means that specific stakeholders and their characteristics are not considered in those studies

Table 2.5 Review of green literature on the construction sector (continued)

Study	Country	Methodology	Primary Focus	Stakeholder; and their Characteristics*	Key Findings
Zhang et al. (2011)	China	Survey	Green strategy for competitive advantage	-	<p>Green design practices: Environmental impact assessment of design, optimising building orientation for better energy performance, consideration for natural lighting, natural ventilation, solar panels, energy efficient HVAC systems, provision for using fabricated materials, and consideration of environmentally friendly materials</p> <p>Green construction practices: Use of environmentally friendly materials, use of pre-fabricated materials, application of onsite waste management</p> <p>Barriers to green practices: High cost of implementation, shortage of green professionals, lack of knowledge and awareness, lack of clarity in tender specification, and conflict of stakeholder interests</p>
Liu et al. (2012)	China	Survey	Drivers and barriers to green practices	-	<p>Drivers of green practices: Support and incentives from the government and to gain social reputation</p> <p>Barriers to green practices: Shortage of green building professionals, high cost of implementation and lack of green construction knowledge</p> <p>Green design practices: Selection of sustainable sites, consideration in design to reduce material usage, use more environmentally friendly materials and have more natural luminance and ventilation as well as provision for water reduction and recycling</p>

*Blank means that specific stakeholders and their characteristics are not considered in those studies

Table 2.5 Review of green literature on the construction sector (continued)

Study	Country	Methodology	Primary Focus	Stakeholder; and their Characteristics*	Key Findings
Ng et al. (2012)	Generic	Literature review	Carbon dioxide reduction strategies across the lifecycle of a building	-	<p>Green design practices: Provision in design for natural ventilation, natural lighting, renewable energy integration, low energy lighting, cooling and heating systems</p> <p>Green purchasing practices: Selection of materials with low embodied energy and high recycled content</p> <p>Green construction practices: Use of fuel-efficient machinery (onsite) and prefabricated materials (offsite)</p> <p>End of life demolition: Recycling and reuse of material</p>
Carris et al. (2012)	UK	Case study	Sustainability in supply chain	-	<p>Drivers of sustainable supply chain: Enhancing reputation, client requirements, regulation/legislation, corporate sustainability objectives, cost reduction</p> <p>Barriers to sustainable supply chain: Lack of awareness and knowledge, high cost of research and development for implementing sustainable practices</p>
Akadiri and Fadiya (2013)	UK	Survey	Drivers of environmental practices	Small, Medium and Large firms	<p>Drivers of environmental practices: Government regulation, pressure from clients, pressure from environmental non-government organisations, top management commitment towards environment and improving company image</p>
Shi et al. (2013)	China	Survey	Barriers to green construction	Developer, Consultant and Contractor	<p>Barriers to green construction: Additional costs for green construction, lack of awareness and knowledge, and shortage of green suppliers</p>
Zutshi and Creed (2014)	Generic	Literature review	Environmental Management System (EMS)	-	<p>Barriers to EMS: High cost of implementation, lack of stakeholder cooperation, lack of trained staff and expertise, long registration process for ISO 14001 certification</p> <p>Economic benefits: Lower material and energy costs and reduction in environment related fines</p>

*Blank means that specific stakeholders and their characteristics are not considered in those studies

2.3.1. Gaps pertaining to green practices

This section critically examines the gaps pertaining to green practices sub-themes, namely, core green practices and facilitating green practices.

2.3.1.1. Gaps pertaining to core green practices

As mentioned earlier, core green practices are activities/initiatives undertaken to minimise the environmental footprint across each of the distinct functional stages of the supply chain, i.e. from design to end of life of the building.

Design phase: It is apparent from Table 2.5 that only a few studies (Liu et al., 2012; Ng et al., 2012) have looked at green design practices, which involve integrating environmental aspects during design stage, despite being 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. Moreover, these few studies have not considered the individual supply chain stakeholders' perspectives. As a result, the details of the relevant green design contribution of individual stakeholders, i.e. Developers, Architects/Consultants, Contractors and (material) Suppliers, is unclear. For example, in the case of Suppliers, green product/material design will have a direct impact on the life-cycle energy efficiency of the building. However, there is little understanding of the impact, as none of the existing studies appears to have investigated the green material/product design aspects of Suppliers. Similarly, Contractors, based on their onsite project experience, could contribute to green building design by suggesting design attributes that consume fewer materials and energy during construction. Again, there is little understanding of the role of Contractors in green building design. A clear understanding of the roles and contributions of individual stakeholders in green design is important for practitioners and policymakers seeking to promote sector-wide energy efficient design practices.

Purchasing/Procurement phase: Purchasing/Procurement is an integral process of any construction project that includes all activities related to acquiring goods, services and consultancy necessary to accomplish the project objectives (Martins, 2009; Sears et al., 2008). Green purchasing or integration of environmental considerations into purchasing policies, programs, and actions (Varnas et al., 2009) has, therefore, the significant potential in greening the construction supply chain. However, as seen in Table 2.5, only a limited number of studies have looked at the green purchasing aspects (Ofori, 2000; Varnas et al., 2009). Moreover,

these studies have either ignored stakeholders' perspectives completely (Ofori, 2000) or considered only specific ones such as Developers (Varnas et al., 2009) in their investigations. The green purchasing practices of various stakeholders are therefore not clear. For example, instead of selecting the lowest bid, which has been the traditional approach to construction procurement for many decades (Hatmoko, 2008), it is important to understand 'what green/environmental consideration is made by the Developer while procuring the services of Architects/Consultants and Contractors'. In the case of Contractors, this understanding is especially important as their green purchasing activities involve environmental considerations in both material purchasing decisions and in the selection of Subcontractors.

Transportation phase: One of the major shortcomings evident from the review is that green transportation or practices undertaken to reduce the environmental impact of all transportation-related activities appear to be missing altogether. This is surprising since construction projects typically have a significant amount of transportation activities, which involve both employee transport and material transport. According to Ng et al. (2012), transportation of materials/supplies alone accounts for roughly 6-8% of the carbon emissions in construction projects.

Construction/manufacturing phase: Studies on green construction practices, or practices aimed at minimising the adverse environmental impact during the physical construction of buildings, have also been narrowly scoped with only specific practices such as pre-fabrication (Jaillon et al., 2009) and onsite waste management (Begum et al., 2007) being studied. Although green construction practices are relevant only to Contractors and Subcontractors, the lack of studies in this area implies that there is limited understanding of the various construction techniques aimed at minimising the adverse environmental implications during the build phase. This is a major concern, as construction phase alone can contribute to more than 20% of a building's lifetime energy consumption (Ng et al., 2012).

In the case of construction material Suppliers, the corresponding practice is "green manufacturing", which involves similar practices at the manufacturing sites. However, none of the studies appear to have looked at the green manufacturing practices of construction material Suppliers. This is another major shortcoming because building material manufacturing itself accounts for 10% of global energy use (UNEP, 2010).

End of life phase: End of life green practices are practices undertaken at the end of a building's useful life to carry out energy-efficient demolition activities and to maximise recovery and recyclability of building materials. However, these too, are minimally discussed in the literature despite being known to significantly reduce the environmental burden associated with the construction sector. As Blengini (2009) explains, they can reduce the total life-cycle energy of a building by around 30%, and GHG emissions by approximately 18%. According to Thormark (2002), end of life management is of paramount importance to reduce the embodied energy of building materials. This is because recycling some materials, such as steel or aluminium, can confer savings of more than half the embodied energy as well as significant reductions in the associated GHG emissions (Yan et al., 2010).

In summary, core green practices, including their extents of the implementation at an individual stakeholder level, are not sufficiently understood for the construction sector. Gaining a detailed understanding of the relevant core green practices for each stakeholder individually is important because altogether, they determine the life-cycle environmental impact of a construction project and when aggregated, for the construction sector as a whole. It also makes sense to study these practices together/holistically as there are interactions between them; for example, green design consideration in terms of building materials/components to be used could have implications for green purchasing, green construction and end of life green practices.

2.3.1.2. Gaps pertaining to facilitating green practices

As previously discussed, facilitating green practices are activities/initiatives undertaken at the intra-firm level to build environmental capabilities and resources. It is again apparent from Table 2.5 that only a limited number of studies have examined facilitating green practices, and that too specific practices such as environmental management systems and ISO 14001 certification (Ofori 2000; Shen and Tam 2002; Zutshi and Creed, 2014). The gaps in the knowledge are therefore clearly evident. For instance, there is little understanding of the various environmental training and environmental auditing activities carried out by different stakeholders in the construction sector. A detailed understanding of the nature/details of these practices such as duration of the training/auditing activities, coverage of the training/auditing activities (all employees or select employees; all departments or select departments) and frequency of the training/auditing activities would be useful in realising the

environmental goals of the sector. Still, others such as cross-functional integration (or coordination across different functions and departments) known to facilitate the realisation of green goals in other sectors (Zhu et al., 2012) appear to be missing in the construction literature. Given that construction firms are typically characterised by large numbers of functions and departments, the sector is expected to benefit from coordinated cross-functional teams in green-related decision making, appropriate exchange of green-related information, ensuring commitment of departments to a common green goal, mutual support, and continuous improvement (Adetunji et al., 2008). However, at present, there is no understanding of how this can be achieved or the extent to which it is achieved in the construction sector. Similarly, other relevant facilitating green practices for the construction sector could be missing in the literature (given the limited number of studies), and therefore needs to be explored further.

In short, for all facilitating green practices, details about their nature and their extents of implementation (both known and unknown) are not sufficiently understood. Given that facilitating practices not only directly improve environmental performance (Zhu et al., 2012), but also contribute to improving the core green practices as well (Sarkis et al., 2011; Zhu et al., 2012), getting a detailed understanding of them, and at an individual stakeholder level, is pivotal for the greening the construction supply chain and the sector.

To summarize, a comprehensive understanding of both core and facilitating green practices, and their extents of implementation for each stakeholder can guide practitioners and policy-makers with a solid understanding of ‘what’, ‘how’, ‘how much’ and ‘why’ to implement these green practices, which could ultimately lead to greater green practices adoption across the sector.

This leads to our first research question:

***RQ1:** What core and facilitating green practices are implemented by individual construction sector stakeholders and the extents of their implementation?*

Next, gaps pertaining to the various green drivers and barriers to green practices are explored.

2.3.2. Gaps pertaining to green drivers and barriers

As previously mentioned, it is important for practitioners and policymakers to understand the ‘antecedents’ or drivers and barriers of core and facilitating green practices, as they can

explain aspects such as why some firms are proactive in implementing green practices while others are reactive; and why some show extensive implementation of green practices while others show limited or no implementation. Like other sectors, the construction sector could also benefit from looking at these drivers and barriers based on their source of origin (external or internal). While the literature has some information on the nature of these external and internal green drivers and barriers (see Table 2.5), the understanding is far from comprehensive.

One of the reasons for this lack of comprehensive understanding of green drivers and barriers is that the studies that have investigated these drivers and barriers in the construction sector are limited in number. Also, these studies are either descriptive or generic, i.e. without stakeholder focus (Zhang et al., 2011; Liu et al., 2012), or have investigated drivers for specific green practices such as green construction (Qi et al., 2010), or barriers for specific green practices such as green purchasing (Sourani and Sohail, 2011) with limited stakeholder focus. Moreover, some important drivers appear to be missing. For instance, consumer pressure, which is identified as a key driver for greening in other sectors, has seen little or no investigation in the context of construction. Consumer pressure for green buildings can be expected to be significant given the significant energy and water savings as well as health benefits from non-use/less use of hazardous materials in such buildings (WGBC, 2013). Similarly, other drivers and barriers may also be missing in the literature.

Therefore, a comprehensive investigation is warranted to unearth the nature/details of various drivers and barriers. This includes identifying the various drivers and barriers based on their source of origin (external and internal), and their perceived importance/relevance by different stakeholders. For example, external pressure from the government in the form of regulations on Developers could be higher or lower compared to the governmental pressure on Contractors. Also, even if all Developers face the same government regulation, some may consider it very important, while others may consider it less important or may choose to ignore it all together. Similarly, shortage of green professionals, a barrier to green practices in construction, could be perceived as a greater or lesser barrier by different stakeholders and individual firms depending on their ability to manage it. In short, the perceived importance of these external and internal drivers and barriers could vary among the supply chain

stakeholders and firms depending on their conflicting interests and their ability in managing these drivers and barriers.

To summarize, a comprehensive understanding of external and internal green drivers, and external and internal barriers for each supply chain stakeholder (i.e. Developer, Architects/Consultant, Contractor/Subcontractor and Supplier) is important for practitioners and policymakers to predict the sector's green behaviour and to devise strategies for each stakeholder so that they can maximise/leverage the drivers and minimise/eliminate the barriers for improving sector-wide efficient and effective green practices. This leads to the next research question:

***RQ2:** What are the green drivers and barriers (external and internal) for implementing green practices (core and facilitating) for individual construction sector stakeholders and their perceived importance/relevance?*

Next, gaps pertaining to 'green performance' or related performance outcomes from implementing green practices are discussed.

2.3.3. Gaps pertaining to green performance measures used and performance benefits from green practices

Knowing the outcomes or performance improvement from green practices (implementation) is important as it directly relates to decision making at all levels: strategic, tactical and operational. This is particularly important for the construction sector, as the sector is known for its poor performance and low-profit margins (Agapiou et al., 1998, Yeo and Ning, 2002, Cox and Ireland, 2002). Regardless of how effective and innovative a new construction strategy or processes may be, its acceptance in the sector will depend heavily on the issues, among others, relating to budget overruns, the risk of delays and quality (Kornelius and Wamelink, 1998, Vrijhoef and Koskela, 2000, Saad, 1996). Therefore, for the sector, adoption of GSCM philosophy, an environmental innovation strategy in itself, would require credible evidence of performance improvements. However, this first requires suitable (green) performance measures to be available. So first, the gaps pertaining to the use of green performance measures across stakeholders in the construction sector are examined.

2.3.3.1. Gaps pertaining to the use of green performance measures

Performance measures in general help firms to evaluate and report performance, identify problems and bottlenecks, set new objectives and targets, determine future courses of actions and enable internal and external benchmarking (Gunasekaran et al. 2004; Björklund et al., 2012). As highlighted earlier, the three important categories of green performance measures that are widely used in other sectors are environmental (Zhu and Sarkis, 2004; 2007; Laosirihongthong et al., 2013), cost/economic (Zhu and Sarkis, 2004; Zhu et al., 2007b; Green et al., 2012) and organisational performance (Green et al., 2012), with the latter two being particularly important from a business perspective (Buyukozkan and Cifci, 2012).

It is evident from Table 2.5 that the focus of studies that have looked at green-related performance measures are mostly skewed towards environmental performance measures (Tam et al., 2006; Gangolells et al. 2009; Chen et al., 2010; Fernández-Sánchez and Rodríguez-López, 2010). This is not surprising given that the *raison d'être* for implementing green practices is to improve a firm's environmental performance; however, to sustain the investment in green practices it is equally important for firms to identify the business benefits. Also, there is a lack of consistency on the environmental performance measures reported in the literature. For example, Gangolells et al. (2009) have considered 20 sub-measures, whereas Fernández-Sánchez and Rodríguez-López (2011) have considered only 12. This inconsistency in the use of performance measures could lead to indifferent performance outcomes (Laosirihongthong et al., 2013).

On the other hand, only a small number of studies have looked at the cost/economic performance measures (Chen et al., 2010; Fernández-Sánchez and Rodríguez-López, 2010). Here also, there is inconsistency in the cost/economic performance measures reported. Moreover, for both environmental and cost/economic performance, measures are defined from an overall project perspective rather than from the perspective of individual stakeholders, which would have been more practically relevant.

However, a major pitfall evident in the literature is that none of the studies appear to have looked at organisational performance measures from a greening perspective. These measures consider the long-term implications of greening such as improvement in corporate/brand image and resulting sales, profits and market (Green et al., 2012), and are critical for justifying

investments in green practices which are significant in the case of the construction sector (WGBC, 2013).

Overall, the lack of use of performance measures, especially those measures that are critical from a business perspective, is clearly evident. Also, there is a lack of consistency in the performance measures used. This could cause uncertainty among practitioners in the construction sector about whether to or to what extent to invest in green practices, thereby limiting the overall greening of the sector.

Next, the gaps pertaining to the actual performance improvement/benefits from green practices reported in the literature are explored.

2.3.3.2. Gaps pertaining to performance benefits/improvements from green practices

Having green performance measures alone is not sufficient though; evidence of actual performance improvement from green practices (through the application of these measures) is also needed. Here again, very little research has been done on the construction sector. The review has come across only two studies that have assessed the actual green performance (Gangoellis et al., 2009; Jaillon et al., 2009). However, both had a narrow focus. For instance, Gangoellis et al.'s (2009) focus were limited to the environmental performance of construction projects, whereas Jaillon et al.'s (2009) assessment of environmental and economic performance was narrowed to a specific green construction practice of pre-fabrication.

In summary, to encourage sector-wide green practices' implementation, a detailed understanding of the important performance measures used to capture the benefits of green practices' implementation across all three categories (environmental, cost/economic and organisational), as well as evidence of actual improvements in them, is required at an individual stakeholder level. This understanding is not available at present and therefore leads to the next research question:

RQ3: What green performance measures (in environmental, cost/economic and organisational terms) are used by individual construction sector stakeholders and the extents of improvement in them from implementing green practices (core and facilitating)?

Now that each GSCM themes/sub-themes and their pertinent gaps have been explored, understanding the relationships between GSCM themes for each stakeholder is important for further understanding the scope of both problems and the opportunities associated with GSCM. Next, this review identifies and explores what is known/unknown with regards to the key relationships between GSCM themes/sub-themes in the construction sector.

2.3.4. Gaps pertaining to relationships between GSCM themes/sub-themes

The interconnected nature of the various GSCM aspects implies that assessing the interrelationships between them such as between green drivers/barriers and green practices' (implementation) and between green practices' (implementation) and performance are very important for practitioners and policymakers to promote GSCM in the construction sector. For example, high perceived importance/relevance attached to external drivers does not necessarily translate into organisational actions in the form of high extent of green practices' implementation. Similarly, high extent of green practices' implementation does not necessarily translate into high performance, as it also depends on the choice of practices and the efficiency and effectiveness of the implementation. Also, not all green drivers and barriers impact all green practices. Similarly, not all green practices impact all three dimensions of green performance. Further, some drivers and barriers impact green practices more than others, and some practices impact performance more than others. Therefore, understanding all these relationships are important to better understand the scope of both the problems and the opportunities associated with GSCM across stakeholders. For example, the practitioner could prioritise the implementation of the green practice that yields the highest performance.

The following sections will discuss the pertinent gaps with regards to the important GSCM relationships for the construction sector.

2.3.4.1. *Gaps pertaining to relationships between green drivers, barriers and practices*

Knowing the relevant relationships between green drivers (external and internal) and green practices (core and facilitating) and between green barriers (external and internal) and green practices (core and facilitating) and, furthermore, for each stakeholder is critical in understanding 'how' and 'to what extent' these pressures (their strengths and their perceived importance/relevance) have translated into organisational actions (or lack thereof), i.e. green

practices' implementation. For example, studies have shown that the relationships between external drivers (perceived importance/relevance) and green practices' implementation 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 organisational choices on green practice implementation and hence the ability to implement innovative 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 regulatory pressure, but not customer pressure, impacts green practice implementation (Lin and Ho, 2011), while others have found all these pressures impact green practices' implementation (Lai et al., 2011). In short, although green drivers (both external and internal), in general, are expected to have a positive impact on core and facilitating green practices, there could be situations where no relationships may exist between various pressures and the extent of green practices implementation. Conversely, it could be argued that although barriers (both external and internal), in general, are expected to have a negative impact on core and facilitating green practices, there could be situations where high external or internal barriers do not necessarily mean low levels of green practices implementation. Therefore, understanding these relationships are useful for practitioners and policymakers to prioritise actions to maximise green practice implementation across the sector. However, given that the net green practices implementation (core and facilitating) depends on the force field impact of these opposing pressures of drivers (external and internal) and barriers (external and internal), it is important to assess these relationships together.

Unfortunately, in the review of GSCM-related studies in the construction sector in Table 2.5, only one study (Qi et al., 2010) discusses the relationship between drivers and green practices implementation; moreover, only a select few drivers are considered and that too only for Contractors. Moreover, none of the studies reviewed has looked at the relationships between green barriers and green practices.

This gap in the literature demonstrates a significant need to assess these relationships for each stakeholder in the construction sector. This leads to the next research question:

RQ4: How and to what extent do green drivers and barriers (external and internal) impact green practices (core and facilitating) for individual construction sector stakeholders?

However, to comprehensively answer the above research question, it is necessary to assess the relationship both at the strategic (higher) level and at the operational/implementation level for each stakeholder.

The strategic level or high-level assessment involves understanding the relationships at the construct level (multi-dimensional conceptualization of several related items) such as between external drivers (combined) and core green practices (combined). It provides a higher level of abstraction beyond the individual items and factors. In simple terms, it looks at the strength of the collective impact of external drivers on collective core green practices. Usually, these GSCM assessments necessitate use of advanced statistical analysis such as multiple regression (Zhu and Sarkis, 2007; Lee, 2008; Zailani et al., 2012) and structural equation modelling (Green et al., 2012; Giovanni and Vinzi, 2012; Lee et al., 2012; Hsu et al., 2013). Also, it requires large samples (typically in excess of 100 collected through surveys), as these generalisations are made for a wider population (Giovanni and Vinzi, 2012). Several studies in other sectors have looked at these higher-level relationships between green drivers and green practices (Hsu et al., 2013; Zhu et al., 2013).

The interested parties of these high-level assessments include government policymakers and industry leaders since they can assess the effectiveness of their policies and efforts in improving the overall green practices of the sector. For example, it helps to understand whether the construction sector is reactive or proactive by assessing the strength of the relationship between external drivers and green practices and between internal drivers and green practices. It is known that a reactive sector (driven by external pressures) may not be sustainable in the long run and for sustaining the green practices a right mix of both external and internal pressures is required. Similarly, assessing the strength of the relationship between external barriers and green practices and between internal barriers and green practices across all stakeholders could enable government policymakers to prioritise their intervention to eliminate/minimise either external or/and internal barriers.

Therefore, some of the potential relationships between green drivers and practices and between green barriers and green practices of interest could be hypothesised as follows:

H4.1: External drivers positively impact core green practices.

H4.2: External drivers positively impact facilitating green practices.

H4.3: Internal drivers positively impact core green practices.

H4.4: Internal drivers positively impact facilitating green practices.

H4.5: External barriers negatively impact core green practices.

H4.6: External barriers negatively impact facilitating green practices.

H4.7: Internal barriers negatively impact core green practices.

H4.8: Internal barriers negatively impact facilitating green practices.

These hypotheses test results could provide valuable insights to answering the research question at the strategic (higher) level.

On the other hand, at an operational/implementation level, the focus typically is on specific green practices. The knowledge on the impact of individual green drivers and barriers here would, therefore, need to be from the perspective of individual green practices' (implementation) so that managerial intervention at an operational/ implementation level can be appropriately focussed. This is because individual green drivers and barriers could impact each green practice's implementation differently, and that too could vary across stakeholders. For instance, the positive/negative impact of a specific driver/barrier on a specific practice's implementation could be no/low, moderate or strong. Since firms are not entirely powerless in terms of their ability to manage, they could utilise this knowledge to identify and prioritise strategies and actions for those drivers and barriers that have a strong and broad impact on green practices implementation. Firms with knowledge of these one to one relationships (which have not been looked at previously in the construction sector) between each green driver/barrier and each green practice's implementation would, therefore, be able to better leverage the drivers and/or mitigate the barriers (in pursuit of green practices' implementation). Similarly, this could help government policymakers to evaluate the effectiveness of government regulation in terms of their strength and ability to influence multiple practices.

Although the strength of the relationships could be assessed quantitatively using statistical methods such as correlation and regression using survey data, comprehensive understanding of 'what', 'why', 'how' and 'how much' one to one impact of drivers and barriers on green practices warrants in-depth investigation typically through multiple interviews. This is

because interviews render deep and rich explanations to the study's research questions that would not likely be possible through the use of quantitative methods such as survey research (Carter and Dresner, 2001), especially when 'how' or 'why' questions are being asked (Yin, 2003). Several GSCM studies in sectors such as manufacturing have used interviews to gain an in-depth understanding of the GSCM aspects (Zhu et al., 2005; 2012a; Azevedo, et al., 2011). A similar approach in the construction sector could garner rich systemic insights to the impact of drivers and barriers on green practices at the operational/implementation level.

2.3.4.2. Gaps pertaining to relationships between green practices and performance

It is important to assess the relationship between green practices and green performance since the adoption of green practices does not necessarily guarantee improved performance, as it also depends on the efficiency, effectiveness and alignment of the green practices to the desired performance goals (Sarkis and Dijkshoorn, 2007). Unfortunately, none of the studies reviewed in the construction sector (Table 2.5) has looked at the relationships between green practices and any of the green performance aspects (environmental, cost/economic and organisational).

As mentioned earlier, the *raison d'être* for implementing green practices is that it 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 other sectors that green practices, both core and facilitating independently of each other, can positively improve environmental performance, but to varying extents (Zhu and Sarkis, 2004; Green et al., 2012; Zhu et al., 2012). From a construction sector perspective, assessing and comparing the strength of the impact of green practices (core and facilitating) on environmental performance for each stakeholder is important for understanding whether green investments are achieving the desired environmental goals.

Also, as mentioned earlier, firms implement green practices not only to achieve their environmental objectives but also from a business perspective such as to obtain short-term benefits in the form of improved cost/economic performance. Ideally, firms must achieve this "win-win" situation to rationalise the investment in green practices. Though several studies have assessed these relationships in other sectors (Zhu and Sarkis, 2004; Zhu et al., 2007a;

Rao and Holt, 2005; Green et al., 2012; Zailani et al., 2012; Lee et al., 2012; Laosirihongthong et al., 2013), there is still little consensus in the literature that green practices could lead to improved cost/economic performance. Understanding this relationship is important for the construction sector because if found positive, it will provide the substantial impetus for firms to implement green practices.

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 organisational 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' organisational 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 from a long-term perspective.

To summarise, it is important to know how core and facilitating green practices impact three dimensions of green performance, namely environmental, cost/economic and organisational performance in the construction sector. Divided views from other sectors on the 'win-win's', or tradeoffs among these relationships (Seuring and Muller, 2008; Zhu et al., 2012) make it even more important to assess these relationships for the construction sector. Ideally, for the construction sector, these relationships should be win-win, i.e. core and facilitating green practices should improve all three dimensions of performance. Nevertheless, assessing these relationships is a step in the right direction towards achieving sector-wide efficient and effective implementation of green practices. It would enable practitioners to prioritise the implementation of facilitating and/or core green practices to deliver the firm's targeted green performance goals (taking all three performance aspects into consideration). Furthermore, it would also enable firms to identify and make improvements (efficiency and effectiveness of implementation) to those existing core and/or facilitating green practices found to be lagging in delivering the desired green performance. This leads to the next research question:

RQ5: *How and to what extent do green practices (core and facilitating) impact green performance (environmental, cost/economic and organisational) for individual construction sector stakeholders?*

Here also, to comprehensively answer the above research question, it is necessary to assess the relationships both at the strategic (higher) level and at the operational/implementation level for each stakeholder.

This strategic level assessment would explore the relationship between green practices and green performance at the construct level. This would be useful for industry leaders and policymakers to assess the success of green practices at the sectorial level and, if required, to make necessary policy/managerial intervention.

Therefore, some of the potential relationships between green practices and performance of interest at the strategic level could be hypothesised as follows:

H5.1: Core green practices positively impact environmental performance.

H5.2: Facilitating green practices positively impact environmental performance

H5.3: Core green practices positively impact economic performance.

H5.4: Facilitating green practices positively impact economic performance.

H5.5: Core green practices positively impact organisational performance.

H5.6: Facilitating green practices positively impact organisational performance.

On the other hand, at an operational/implementation level, understanding how individual green practices (both core and facilitating) impact three dimensions of green performance, namely environmental, cost/economic and organisational performance (one to one assessment), would enable practitioners to prioritize the implementation of those facilitating and/or core green practices that deliver the firm's targeted green performance goals (taking all three performance aspects into consideration).

This is important because, in reality, most firms would start with the implementation of one or a small number of green practices. Therefore, it is vital that these individual green practices, even as standalone, contribute towards green performance, though, ideally, implementation of all or several green practices is better because it makes each practice more

efficient and effective, as these practices complement each other well. It would also enable firms to identify and make necessary improvements (efficiency and effectiveness of implementation) to the core or/and facilitating green practices that are found to be lagging in delivering the desired green performance.

2.3.4.3. *Gaps pertaining to the relationship between facilitating and core green practices*

Studies have shown that ‘having your house in order’, i.e. having strong internal green resources and capabilities (facilitating green practices) could lead to the efficient and effective implementation of core green practices (Zhu et al., 2012; 2013). Studies that have investigated these relationships have observed them 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 core practices. Zhu et al. (2012) emphasised the importance of functional coordination between facilitating and core green practices to enhance the environmental, economic, and organisational performance benefits. Yu et al. (2014) also found significant positive relationships between facilitating and core green practices and recommended simultaneously considering the implementation of both practices. The study also gave warning of the dangers of overlooking either facilitating or core green practices.

Unfortunately, these relationships have not been assessed previously in the construction sector. This leads to our next research question:

RQ6: How and to what extent do facilitating green practices impact core green practices for individual construction sector stakeholders?

Here it is again necessary to understand the relationship both at the strategic level and at the operational/implementation level. Strategic level understanding of this relationship has significant policy implications. For example, a strong and positive relationship between facilitating and core green practices implies policymakers could consider making facilitating green practices (few or all of them) mandatory for construction firms.

Therefore, the potential relationships between core green practices and facilitating green practices at the strategic level could be hypothesised as follows:

H6.1: Facilitating green practices positively impact core green practices.

On the other hand, at the operational/implementation, the one to one knowledge of the relationship between each facilitating green practice and core green practice would enable practitioners to prioritise their implementation of those facilitating green practices that have broader and stronger impact on core green practices. Also, it allows firms to re-assess their existing internal capabilities such as the effectiveness of their environmental training and auditing activities in improving their core green practices. Further, it helps firms to execute functional realignment of facilitating green practices to improve all or specific core green practices in line with organisational goals.

Now that the gaps pertaining to GSCM themes/sub-themes and their relationships have been established, next what is known/unknown with regards to the influence/impact of firm characteristics will be explored, namely size and ownership on the various GSCM themes/sub-themes in the construction sector.

2.3.5. Gaps pertaining to the impact/influence of firm size and ownership on GSCM themes/sub-themes

In the generic review (review of studies in other sectors) of GSCM, the two important firm characteristics that received much attention was firm size (Gonzalez et al., 2008; Lee, 2008; Zhu et al., 2007a; 2008b; Hassini et al., 2012) and firm ownership (Zhu and Sarkis, 2007; 2008c; 2011; 2012a; Henri and Journeault, 2008). This is important because a typical supply chain will comprise several firms with varying sizes and ownership; since overall green performance of the supply chain is directly linked to the commitment and participation of all firms, this understanding could enact policy interventions and support mechanisms to assist those firm types based on size (small, medium and large) or/and ownership (local, foreign and joint venture), depending on who is lagging behind in improving their green practices and performance.

This understanding is even more significant for the construction sector given that a typical construction supply chain consists of hundreds, if not thousands of firms with varying size and ownership. Unfortunately, the influence of firm size and ownership is not sufficiently understood for the construction sector. As seen in Table 2.5, only a few studies have discussed the influence of firm size on GSCM. Notably, none of the studies in Table 2.5 has investigated the influence of ownership on GSCM. Even the few studies that looked at the influence of firm size on GSCM are narrowly focused, looking at the influence of firm size on only certain GSCM

aspects. For instance, Abidin (2010) investigated the influence of firm size on the environmental awareness of Malaysian Developers; whereas Qi et al. (2010) and Akadiri and Fadiya (2013) looked at the influence of firm size on green practices. Similarly, Tam et al. (2006) examined the difference in the use of environmental performance measures between large, medium and small Contractors. Apart from this, there is no understanding of the influence/impact of firm size and firm ownership on all the GSCM themes/sub-themes in the construction sector.

This leads to our next and final research question:

RQ7: How and to what extent do firm size and firm ownership impact GSCM themes/sub-themes in the construction sector?

The study acknowledges that this is a broad research question compared to other research questions proposed in this thesis. Therefore, the following sections will explore further how firm size and firm ownership have influenced other sectors and based on which predictions (hypotheses) can be made on the potential impact of firm size and ownership on the various GSCM themes/sub-themes for the construction sector. In short, the study will attempt to break this broad research question into sub-questions and testable hypotheses.

First, the impact of firm size on GSCM themes/sub-themes are critically discussed.

2.3.5.1. Impact of firm size on GSCM themes/sub-themes

Firm size has long been considered as a significant contingency variable in macro-organisational studies (Kimberly, 1976). It was found to influence/predict several aspects of a firm, including its environmental aspects (Chen and Hambrick, 1995; Baylis et al., 1998; Grant et al., 2002). Therefore, evidence-based understanding of the moderating influence of firm size on the various GSCM themes (i.e. green practices, green drivers, green barriers and green performance) for the construction sector is critical for industry leaders, practitioners, and policymakers to enact strategies and policies to promote green practices across firms of all sizes. The following sections will discuss the impact of firm size on each GSCM themes/sub-themes, starting with green practices.

2.3.5.1.1. Impact of firm size on green practices

For wide greening the sector, it is important to know the nature and the extent of implementation of green practices of small, medium and large firms in the supply chain. That

is, whether the different-sized firms are implementing higher, lower or equal levels. Significant differences in green practices among different-sized firms imply that different strategies and policies are required from industry leaders, supply chain partners and government policymakers to aid SMFs or large organisations (depending on which is lagging) in improving their green practices.

The evidence in the literature is skewed towards large firms implementing more green practices than small and medium firms (SMFs). This is not surprising given that large firms have more resources, increased specialisation of skills and functions and hence more flexibility to dedicate resources to strategic supply chain activities such as GSCM than SMFs (Zhu et al., 2008b). For example, Florida (1996) examined the effects of firm characteristics on the adoption of several environmental innovations, including source reduction, pollution prevention, and green product designs and found that the incorporation of green practices varied positively with organisation size (measured as the number of employees). Core green practices such as green design and green purchasing were also found to be higher among large firms (Zhu et al., 2008b). Similarly, Arora and Cason (1996) found a positive and significant relationship between firm size and participation in voluntary environmental programs. An investigation among Spanish firms by Aragón-Correa (1998) found the environmental training programs of large firms to be higher than that of small firms. A large-scale empirical study by King and Lenox (2001) using a sample of 16,782 U.S. manufacturing firms found that large firms are more likely to adopt ISO 14001 standard. A similar finding is reported by Zhu et al. (2008b), who found ISO 14001 certification and establishment of environmental management systems have significant implementation differences among SMFs and large firms. Lee (2008) found the willingness to participate in green supply chain initiatives to be more among large firms than SMFs.

More recent studies have also shown that the implementation of green practices is higher among large firms. Ben Brik et al. (2013) found a positive association between firm size and green practices among UAE manufacturing firms. Mohanty and Prakash (2014) found a positive association between size and environmental actions including the end of life management using data collected from furniture and packaged goods industries. Several studies have shown that the implementation of EMS and ISO 14001 is higher among large firms than smaller firms (Tambunlertchai et al. 2013; Blackman and Guerrero 2012).

Vijayvargy et al. (2017) reported green design and green purchasing practices of large firms to be higher than small firms.

This situation of SMFs implementing green practices at a lesser scale is a concern because of their sheer number (more than 80% of all global firms are SMFs) as well the fact that they account for approximately 70% of global environmental pollution (Hillary, 2004; Lee, 2009). SMFs, therefore, can be a source of environmental risk and a bottleneck in the pursuit of greener supply chains. Hence, their participation and commitment to the implementation of green practices are critical for greening any sector (Holt et al., 2001).

However, contrary to the popular findings, few studies have found negative or no association between firm size and green practices. For example, Zhu et al. (2007a) found a negative association between firm size and green practices including green design, green purchasing and several facilitating green practices among Chinese automotive firms. Similarly, Vachon (2007) and Vachon and Klassen (2007) found pollution prevention technologies to be lower for large firms. Min and Galle (2001) found no significant influence of firm size (number of employees) and green purchasing behaviour. Similarly, a study by Gonzalez, Sarkis and Adenso-Diaz (2008) found no significant relationship between organisational size and green design in the Spanish automotive sector.

The negative or no association between firm size and green practices could be because of the large firm's resistance to change business practices (organisational inertia) (Miller and Chen, 1994). This organisational inertia could be high for firms with multiple layers of management, several departments and bureaucratic structure (Daft, 1995). Some authors have argued that large firms would be reluctant to adopt practices or technologies they are unfamiliar or less familiar with (Nelson and Winter 1982). Hannan and Freeman (1989) mentioned that firms' ability or motivation to adopt new environmental technologies reduces as their size increases. Also, green practices are not expected to increase indefinitely as firms grow larger.

These indifferent results or propositions make it even more important to understand the impact of firm size on green practices for the construction sector. At present, there is very little understanding of the influence of firm size on green practices in the construction sector. This review could only find two studies that have examined the influence of firm size on green practices (Qi et al., 2010; Begum et al., 2009). However, the focus of these studies was limited

to Contractors. Moreover, there is a lack of consensus on the influence of firm size on green practices. For instance, Qi et al. (2010) found that large firms are statistically more likely to implement green construction practices than smaller firms among Contractors in the Chinese construction sector. In contrast, Begum et al. (2009) found small Contractors exhibit more satisfactory behaviours regarding waste management as compared to large contractors.

Hence from a construction sector perspective, understanding the influence of firm size on the green practices, inclusive of all stakeholders, is important for promoting green practices across firms of all sizes. This leads to a more focused (sub) research question within RQ7.

RQ7.1: How and to what extent does firm size impact the implementation of core and facilitating green practices in the construction sector?

Since the evidence in the literature is tilted towards large firms implementing more green practices than SMFs, the following hypothesis can be formulated:

H7.1.1: Core green practices' implementation is greater for large firms than SMFs.

H7.1.2: Facilitating green practices' implementation is greater for large firms than SMFs.

Next the impact of firm size on green drivers is discussed.

2.3.5.1.2. Impact of firm size on green drivers

Firm size could also influence the drivers of green practices. For instance, large firms could face more green-related government regulation than SMFs. Moreover, even if both large firms and SMFs face the same governmental pressure, the importance attached to these pressures could vary among firms. Therefore, it would be useful to understand the influence of firm size on the strength and/or the perceived importance/relevance attached to these drivers by firms. These rich insights enable any sector to enact policies and support mechanisms to ensure firms of all sizes can leverage these drivers to successfully implement green practices.

Looking at external drivers first, the evidence from the generic review shows that large firms face more direct external pressures such as extra regulatory burdens to maintain higher environmental standard than smaller firms (Russo and Fouts, 1997). Smaller firms, on the other hand, were found to receive less or no regulatory pressure. For example, in the US, the Small Business Regulatory Environment Fairness Act (SBREFA) of 1996 stipulates that the

Environmental Protection Agency (EPA) give special treatment and exemptions from environmental regulations and taxes for small firms (Grant et al., 2002). Also, studies have shown that SMFs consider external pressures less seriously than large firms, as they know because of their sheer number they may not be subject to compliance inspections (Zhang et al., 2008).

Grant et al. (2002) highlighted that large firms not only face heightened regulatory pressure to implement green practices than SMFs but also face pressure from NGOs, stakeholders and public media. González-Benito and González-Benito (2006) also reported that large firms receive more pressure from their social and economic environment than SMFs. For example, Baylis et al. (1998) found the pressure from supply chain stakeholders to be higher for large firms than SMFs. Similarly, Grant et al. (2002) highlighted that large firms are more likely than small firms to be the subject of negative media coverage for any environmentally irresponsible behavior, whereas SMFs are less likely to receive public and media scrutiny for poor environmental practices, as the general public perception is that SMFs have less environmental impact than large firms.

In the case of the construction sector, there is limited understanding of the influence of firm size on the perceived importance/relevance of these external drivers across stakeholders. The only reference found in the review was by Qi et al. (2010), who highlighted (by citing Zeng et al., 2007; Li et al., 2010) that large Contractors, in general, receive more pressure from governments and NGOs in adopting green practices. Hence, there is a need to understand how firm size influences the external pressures exerted by governments, NGOs, competitors and supply chain stakeholders as well as the importance attached to these pressures by SMFs and large firms across all stakeholders. This leads to the next (sub) research question:

RQ7.2: How and to what extent does firm size impact the external green drivers in the construction sector?

Since the overwhelming evidence in the literature points to external drivers being higher for large firms than SMFs, the influence of firm size on external green drivers for the construction sector can be hypothesised as follows:

H7.2.1: Perceived importance/relevance of external green drivers is higher for large firms than SMFs.

In the case of internal drivers, specifically with regards to environmental commitment, the evidence in the literature is limited with mixed views. For instance, some argue that large firms are more internally driven towards environmental initiatives than small firms as part of their strategy to maintain environmental leadership (Baylis et al., 1998), while others argue that small business is environmentally responsible by nature because of the need to maintain good reputation within the local community (Besser, 1999; BITC, 2002; EMSF, 2004) and/or have a responsible owner (Solymossy and Masters, 2002; Teal and Carroll, 1999). Still, others have found no differences in the environmental commitment of small, medium and large firms (Zhu et al., 2008). However, there is limited evidence in the literature with regards to how different-sized firms view other internal drivers such as the motivation to reduce cost and improve brand image. The only evidence identified in the literature is Baylis et al. (1998), who found the motivation to reduce cost as a green driver to be higher among large firms than SMFs because the cost saving potential in large firms is greater because of their size.

These limited and conflicting findings make it even more important to understand the impact of firm size and internal green drive of firms for the construction sector. So far, only limited studies have investigated the association between internal drivers and firm size in the construction sector. Ofori (2000) highlighted that awareness, interest or commitment to environmental issues was only found among few large Contractors in the UK construction sector. Abidin (2010) reported higher environmental commitment in Malaysia by large Developers than small and medium Developers. However, other than these studies, there is no account of the influence of firm size on the various internal drivers across stakeholders. This understanding could pave the way for improving the internal green drive of firms of all sizes across all stakeholders.

This leads to our next (sub) research question:

RQ7.3: How and to what extent does firm size impact the internal green drivers in the construction sector?

Although there is a lack of consensus in the generic literature relating to internal drivers being higher for large firms than SMFs, based on the limited evidence in the construction sector, the influence of firm size on internal drivers for the construction sector can be hypothesised as follows:

H7.3.1: Perceived importance/relevance of internal drivers is higher for large firms than SMFs.

Next, the impact of firm size on green barriers are discussed.

2.3.5.1.3. Impact of firm size on green barriers

Like drivers, the green barriers faced by the firms in implementing green practices could be different among large firms and SMFs (Vijayvargy et al., 2017). Looking at external barriers first, though there is no direct evidence available in the literature on the impact of firm size on external barriers, it could be reasoned that large firms are in a much better position to manage these externalities than smaller firms. For example, when considering the shortage of green suppliers, one of the external green barriers evident in the construction literature (Shi et al., 2013), it could be argued that because large firms hold more leverage in supplier relationships than small firms, they would be less impacted by a shortage of green suppliers. Previous studies have highlighted the ability of large firms to bargain to get favourable supply terms (such as credit limit, payment period etc.) than smaller firms (Koufteros et al. 2007). On the contrary, small firms typically have less purchasing power; hence, they have little control over their suppliers (Ramsey, 2001). Similarly, perceived strength of other external barriers such as shortage of green building professionals (Liu et al., 2012) could be influenced by firm size. Understanding the difference in the perceived importance/relevance of these barriers between different-sized firms is important so that a more focused support mechanism can be enacted for those firms who are vulnerable to external barriers. At present, there is no understanding on how external barriers are influenced by firm size in construction.

This leads to the next (sub) research question:

RQ7.4: How and to what extent does firm size impact the external green barriers in the construction sector?

Since it can be presumed that large firms will be in a much better position to manage external barriers, the influence of firm size on external barriers for the construction sector can be hypothesised as follows:

H7.4.1: Perceived importance/relevance of external barriers are lower for large firms than SMFs.

In the case of internal barriers, the overwhelming evidence in the literature shows that smaller firms face much greater internal barriers than large firms. This is because SMFs usually lack the information, resources, or expertise to deal with environmental issues. According to the OECD (2007), SMFs suffer from an overall lack of managerial and technical skills and human and financial resources to perform tasks/activities that could help them improve their environmental performance. Others have reported that SMFs are often unaware of their environmental impact or environmental issues in general (Sarkis and Dijkshoorn, 2007; Lepoutre and Heene, 2006). According to Holt et al. (2001), the fundamental differences between SMFs and large firms in environmental management is that SMFs neither have the required in-house expertise to self-manage environmental projects nor can they afford the upfront capital to hire environmental consultants; on the other hand, large firms possess the necessary resources, technical ability, time and capital. Grant et al. (2002) highlighted that financial constraints are less of a barrier for large firms vis-à-vis SMFs; this is because, for large firms, green investments are only a smaller portion of their total assets.

In the case of the construction sector, only a few studies have mentioned the association of internal barriers and firm size. Abidin (2010) reported low internal barriers for applying sustainable practices for large Developers in their projects because of their capital, experience and expertise. Qi et al. (2010) highlighted low internal barriers for large Contractors in the Chinese construction sector because of their investments in technology, human resources or certifications. Although these two studies support the popular wisdom that internal barriers are higher for SMFs than large firms, there is much to be known about the association between internal barriers and firm size. A detailed understanding is key for the construction sector to develop a collective supportive mechanism for firms facing significant internal challenges in implementing green practices. For example, the government should take into consideration the resource constraints of SMFs before applying a specific green regulation as SMFs cannot keep up with the volume of regulations (Qi et al., 2010):

This leads to the next (sub) research question:

RQ7.5: How and to what extent does firm size impact the internal green barriers in the construction sector?

Since the evidence in the literature points to internal barriers being lower for large firms than SMFs, the impact of firm size on internal barriers for the construction sector can be hypothesised as follows:

H7.5.1: Perceived importance/relevance of internal barriers are lower for large firms than SMFs.

To summarise, the proposed research questions and hypotheses would help practitioners and policymakers in the construction sector to understand the heterogeneity in the response to the external and internal drivers and barriers faced by SMFs and large firms in the supply chain.

2.3.5.1.4. Impact of firm size on green performance

Ideally, all firms, regardless of their size, should be able to improve their green performance (environmental, economic and organisational) from green initiatives. However, firm size could influence/moderate the performance improvement.

The evidence in the literature on the impact of firm size on green performance is limited and mixed. For example, Vijayvargy et al. (2017) found the environmental and economic performance of large firms to be significantly higher than that of small firms. Similarly, Gonzalez, Sarkis and Adenso-Diaz (2008) found large firms doing well in the reduction of material usage in the Spanish automotive sector. However, empirical investigation on the effect of firm size on environmental pollution in the US chemical industry by Grant et al. (2002) found that larger plants exhibit significantly greater emission rates than small plants. Zhu et al. (2007a) reported a positive association between firm size and negative environmental performance in the Chinese automotive sector.

In this review of the construction sector literature, no single study was identified that looked at the relationship between actual performance improvement and firm size.

This leads to the next (sub) research question:

RQ7.6: *How and to what extent is the improvement in green performance (in environmental, cost/economic and organisational terms) influenced by firm size in the construction sector?*

Although the evidence in the literature is limited and mixed, for the construction sector, it is presumed that the improvement in green performance across all three dimensions for large

firms is higher than SMFs. Hence, the influence of firm size on the improvement in green performance for the construction sector can be hypothesised as follows:

H7.6.1: The improvement in environmental performance is higher for large firms than SMFs.

H7.6.2: The improvement in cost/economic performance is higher for large firms than SMFs.

H7.6.3: The improvement in organisational performance is higher for large firms than SMFs.

Next, the impact of firm ownership on GSCM themes/sub-themes is discussed.

2.3.5.2. Impact of firm ownership on GSCM themes/sub-themes

Like firm size, firm ownership is also considered as a significant contingency variable in macro-organisational studies that can affect a firm's environmental strategy (Earnhart et al., 2014). Linking GSCM and firm ownership is important because supply chain wide greening would not be possible without the active involvement and participation of both local and foreign firms. This understanding is especially important in a country context that is more open to foreign direct investment that allows foreign firms to start their subsidiaries or enter partnerships with local firms in the form of joint ventures and mergers (Perkins and Neumayer, 2008; Luken et al., 2008). Research on the impact of foreign-owned firms in the environmental context, let alone GSCM, is surprisingly sparse.

Therefore, evidence-based understanding of the moderating influence of firm ownership on the various GSCM themes (i.e., green drivers, green barriers, green practices and green performance; and their relationships) is critical for the concerned authorities/bodies to enact effective strategies and policies to promote extensive, efficient and effective green practices across all firms regardless of their ownership.

2.3.5.2.1. Impact of firm ownership on green practices

So far, the evidence in the generic literature relating green practices implementation and firm ownership, i.e. foreign vis-à-vis local is mixed. Though majority studies reported higher levels of green practices implementation by foreign firms than their local counterparts, some have reported similar or no difference in the green practices implementation levels between foreign and local firms.

For example, Zhu et al. (2011) reported that foreign manufacturers operating in China are generally more active or prepared to undertake proactive green practices than local

manufacturers. Also, studies that have used cumulative foreign direct investment (FDI) as a proxy to study the behavior of foreign firms operating in a country also reported higher levels of green practices, such as EMS and ISO 14001 certifications, by foreign firms than local firms (Christmann and Taylor 2001; Neumayer and Perkins 2004; Prakash and Potoski 2007; Tambunlertchai et al. 2013). Luken et al. (2008) found a positive correlation between FDI and the adoption of technologically complex pollution prevention practices.

On the other hand, Pargal and Wheeler (1996) and Dasgupta et al. (2000) reported no significant difference in the environmental management of firms among foreign and local firms in Indonesia and Mexico respectively. Qi et al. (2011) found no influence of foreign ownership on the adoption of ISO 14001 in China. Similarly, Bluffstone and Sterner (2006) found no evidence that foreign ownership increases the likelihood of firms adopting environmental management practices. Other studies supporting this viewpoint have used the “pollution haven” hypothesis. According to the hypothesis, foreign firms from developed countries are attracted to weak environmental regulations in developing countries, as there is less need to implement stringent environmental practices (Eskeland and Harrison, 2003; Cole and Elliott 2005; Dean et al., 2009).

As evident from Table 2.5, none of the GSCM-related studies in the construction literature has linked firm ownership and any of the GSCM themes/sub-themes let alone green practices. This is a major concern for understanding whether there is any difference in the green practice implementation across foreign and local firms; and if so, knowing whether the differences exist across all practices or select practices, and to what extent is the difference critical for improving the green practices implementation across both foreign and local firms in the construction sector.

This leads to our next research question

RQ7.7: How and to what extent does firm ownership impact the implementation of core and facilitating green practices in the construction sector?

Though the evidence in the literature is mixed, it is slightly skewed towards foreign firms implementing higher green practices than local firms. For the construction sector, the green practices’ implementation of foreign firms can be presumed to be higher than local firms. Hence, the following hypotheses for the construction sector are proposed:

H7.7.1: Core green practices implementation is greater for foreign than local firms

H7.7.2: Facilitating green practices implementation is greater for foreign than local firms

Next, the impact of firm ownership on green drivers are discussed.

2.3.5.2.2. Impact of firm ownership on green drivers

As in the case with firm size, it would be useful to understand whether there is any variance in the extent of pressures faced as well as the importance attached to these pressures among foreign and local firms. Again, this understanding would enable the sector to have policies and support mechanisms in place, so that both foreign and local firms could leverage the drivers and eliminate/minimise the barriers in implementing extensive, efficient and effective green practices.

In the case of external drivers, the evidence in the literature on the extent of pressures faced by firms is mixed. For example, Vernon (1998) highlights that foreign firms face more government regulation and are more often audited and prosecuted than local firms. Similarly, Kim et al. (2016) argues that foreign-owned firms may face more pressure not only from governments but also consumers, and suppliers. Child and Tsai (2005) reported that unfair treatment against foreign firms in China as they face more stringent regulation than local firms, who in turn were found to operate under more lenient terms because of their superior connections with local officials, even though many were financially and technologically capable of meeting more stringent standards. On the other hand, King and Shaver (2001) did not find any evidence to support the assertion that foreign-owned establishments will be more stringently regulated than their domestic counterparts in the United States. According to Earnhart et al. (2014), the regulatory pressure faced by foreign firms will depend on the policymakers' relative interest in attracting foreign direct investment (FDI) versus protecting domestic companies.

However, with regards to the importance given to these external pressures, evidence in the literature shows that foreign firms take these external pressures more seriously than local firms because loss of legitimacy of foreign firms in one country can spill over to their operations in other countries (Kostova and Zaheer 1999; Spencer and Gomez 2011). Moreover, considering external pressures more seriously enables foreign firms to develop and maintain good relations with all concerning external parties such as governments, supply

chain stakeholders, NGOs and consumers, thereby gaining legitimacy and reducing the liabilities of foreignness in host countries (Kim et al., 2016).

Unfortunately, at present, there is no understanding with regards to the impact of foreign ownership on the green drivers in the construction sector. It is important therefore to understand how firm ownership influences the external pressures exerted by governments, NGOs, competitors and supply chain stakeholders as well as the importance attached to these pressures by foreign and local firms in the construction supply chain.

This leads to the next (sub) research question:

RQ7.8: How and to what extent does firm ownership impact the external green drivers in the construction sector?

Based on the evidence in the generic literature and our understanding of the construction sector, the impact of firm ownership on external drivers for the construction sector can be hypothesised as follows:

H7.8.1: Perceived importance/relevance of external drivers is higher for foreign than local firms.

In the case of internal drivers, evidence in the literature suggests that foreign firms are more internally driven to implement green practices than their local counterparts. The high environmental commitment of foreign firms reported in the literature is because foreign firms self-regulate their environmental conduct, participate in voluntary environmental initiatives and adopt internal environmental standards that are more stringent than those mandated by the local governments in developing countries (Dowell et al., 2000). Studies have also shown that most foreign firms are likely to have a global environmental policy that mandates a high level of environmental commitment and standardisation in every subsidiary location (Christmann 2004; Lyon and Maxwell 2004). Also, in the wake of fierce competition, they see this as an opportunity to achieve a sustainable competitive advantage over their local peers (Bach and Allen 2010; Berrone et al. 2007). Previous work in developing countries also suggests that foreign firms are more environmentally responsible than their local counterparts (Eskeland and Harrison, 1997). This view is echoed by other studies which argue that foreign firms are increasingly expected to demonstrate socially responsible leadership in

respect of their environmental policies (Gould, 2004; Margolis and Walsh, 2003, Child and Tsai, 2005).

With regards to the perceived business benefits as a driver of green practices such as reducing costs and improving reputation, the evidence from the literature to some extent shows that foreign firms are more business-driven to implement green practices. For example, Christmann and Taylor (2001) highlight that the environmental strategy followed by a foreign firm in a host country will depend on the perceived business benefits from that strategy. The study also points out that foreign firms through standardising environment strategies across countries could achieve significant cost reduction benefits due to global economies of scale. Furthermore, studies have highlighted that the higher environmental standards of the foreign firm than those required by regulation in the host country is largely driven by the desire to achieve competitive advantage and to have immunity in case the host country regulations are tightened (Porter and van der Linde, 1995; Dowell et al., 2000). Also, to some extent, the motivation to implement state-of-the-art green practices is driven by intangible benefits such as positive reputation (Dowell et al., 2000).

Regrettably, there is as yet no understanding of how firm ownership influences the internal drive of firms in the construction sector. This knowledge is important to ensure firms regardless of their ownership are self-motivated to implement green practices.

This leads to the next (sub) research question:

RQ7.9: How and to what extent does firm ownership impact the internal green drivers in the construction sector?

Based on the overwhelming evidence in the generic literature, it could be argued that foreign firms in the construction sector will be more motivated internally to implement green practices than local firms. Hence, the influence of firm ownership on internal drivers for the construction sector can be hypothesised as follows:

H7.9.1: Perceived importance/relevance of internal drivers are higher for foreign than local firms.

Next, the impact of firm ownership on green barriers are discussed.

2.3.5.2.3. Impact of firm ownership on green barriers

First, looking at the impact of firm ownership on external barriers, unfortunately, there do not appear to be any explicit studies in the generic literature that report the influence of firm ownership on external barriers. However, it could be argued that foreign firms would be in a much better position to mitigate/manage the external barriers faced than local firms. For example, shortage of green professionals, one of the external barriers identified in the construction literature could be a less of a barrier for foreign firms because of their ability to move/transfer green professionals from headquarters and other subsidiary locations.

One the contrary, it could be argued that some of the external barriers would be higher for foreign firms because their understanding of the local business environment, local regulations, customs and culture including language would be limited compared to their local counterparts. For example, Kim et al. (2016) highlight that foreign firms struggle to keep up with local regulations especially if the regulations are written in a local language and revised/changed frequently.

At present, there is no knowledge on how external barriers are influenced by firm ownership in construction.

This leads to the next (sub) research question:

RQ7.10: How and to what extent does firm ownership impact the external green barriers in the construction sector?

Though the evidence in the literature is mixed, it can be presumed that foreign firms, because of their superior knowledge and capabilities, will be in a much better position to manage external barriers. Therefore, the influence of firm ownership on external barriers for the construction sector can be hypothesised as follows:

H7.10.1: Perceived importance/relevance of external barriers are lower for foreign than local firms.

In the case of internal barriers, there is a strong consensus in the literature pointing to internal barriers being less for foreign firms than local firms. This is partly due to the fact that foreign firms have better access to external financing, state-of-the-art technologies, advanced management systems, procedural know-how and cutting-edge practices (Earnhart et al.,

2014; Kim et al., 2016). While local firms suffer from lack of knowledge and experience given that green practices are relatively new in many emerging economies, foreign firms benefit from their extensive international experience (Kim et al., 2016). Also, the high cost of implementation may not be such a barrier for foreign firms vis-à-vis local firms because foreign firms benefit from global economies of scale (Earnhart et al., 2014). Moreover, implementing green practices may not require foreign firms to invest much, as foreign firms may already have these technologies/systems and resources readily available in their home countries (Kim et al., 2016).

It is important to understand these underlying differences for the construction sector so that effective policies and support mechanisms can be applied to ensure all firm regardless of their country of origin can overcome the green barriers facing them.

This leads to the next (sub) research question:

RQ7.11: How and to what extent does firm ownership impact the internal green barriers in the construction sector?

Since the evidence in the generic literature points to these barriers being less for foreign firms than local firms, the impact of firm ownership on internal barriers for the construction sector can be hypothesised as follows:

H7.11.1: Perceived importance/relevance of internal barriers are lower for foreign than local firms.

2.3.5.2.4. Impact of firm ownership on green performance

Like firm size, firm ownership could also influence the green performance of firms. Ideally, for the construction sector, both local and foreign firms should be able to improve their green performance (environmental, cost/economic and organisational).

The evidence in the literature of the impact of firm ownership on the environmental performance benefits of firms is limited and mixed. For example, Eskeland and Harrison (2003) found foreign-owned plants have lower levels of emissions than comparable domestically owned firms. On the other hand, Neumayer (2008) in a multi-country study found varying results between foreign direct investment (FDI) and greenhouse gas emissions.

With regards to cost/economic performance, the evidence in the literature is again limited and mixed. Some authors suggest that proactive environmental management of foreign firms, largely to have environmental standardisation in every subsidiary location, may incur additional costs, resulting in negative financial consequences that outweigh the cost benefits of green practices (Cordeiro and Sarkis 1997; Kim and Statman 2012). On the contrary, several other studies have shown that advanced knowledge and expertise of foreign firms on environmental aspects could result in improved firm performance (Porter and van der Linde 1995; King and Lenox 2002).

Unfortunately, there do not appear to be any studies that looked at the impact of firm ownership on organisational performance.

From the construction sector perspective, knowledge of this impact of firm ownership on green performance would be valuable. However, none of the studies to date in construction have explored the differences in green performance based on firm ownership. This leads to the next (sub) research question:

RQ7.12: How and to what extent is the improvement in green performance (in environmental, cost/economic and organisational terms) influenced by firm ownership in the construction sector?

Though the evidence in the literature is either mixed or not known, for the construction sector, it can be presumed that the green performance improvement for foreign firms is higher than local firms because of their international experience, knowledge and capabilities. Therefore, the influence of firm ownership on the improvement in green performance for the construction sector can be hypothesised as follows:

H7.12.1: The improvement in environmental performance is higher for foreign than local firms.

H7.12.2: The improvement in cost/economic performance is higher for foreign than local firms

H7.12.3: The improvement in organisational performance is higher for foreign than local firms

2.3.6. Other pertinent gaps - Lack of theoretical underpinning and lack of geographical coverage

In addition to the above-mentioned gaps in the GSCM literature in construction, this review has identified two additional gaps in the literature, namely lack of theoretical underpinning

and lack of geographical coverage, both of which need attention. First, the gaps pertaining to the application of management/organisational theories in the construction literature will be discussed.

2.3.6.1. *Gaps pertaining to the application of theories*

A major gap evident in the review of green/GSCM related studies in the construction sector (refer Table 2.5) is the lack of theoretical basis in these underlying studies. In fact, none of the green-related studies in Table 2.5 has used management theories to underpin the findings. Theory enabled understanding is important, as it provides a means to organise information in a way that is internally and externally consistent, verifiable, has generality and possesses scientific parsimony (d'Amboise and Muldowney, 1988). Given the scientific notion that sound theoretical principles are fundamental for decision-making and managerial actions as well as advancement of any field (Chen and Paulraj, 2004), the lack of theoretical basis limits the generalisability and the transferability of the findings in a particular construction sector context to that of another as well across different sectors. Moreover, GSCM as a field of practice in construction is viewed as conceptually immature and underdeveloped. Therefore, there is a strong need for developing a reliable theoretical basis for the construction sector to help clarify the scope and purposes of GSCM in the construction sector as an academic and practice-based discipline which, in turn, could potentially enhance the application of GSCM in construction and in general.

To address this issue, the study will attempt to underpin the findings to established/emerging management theories, depending on where and how these theories can, individually and in combination, contribute to providing a deeper, broader and more simplified conceptualization of GSCM perspectives. This is expected to enhance the generalizability and transferability of GSCM findings in the construction sector in a particular country context to that of another as well across different sectors.

To the best of my knowledge, this would be the first real attempt to introduce theories to underpin GSCM-related findings in the construction sector and it is expected that the explanatory and predictive capabilities of these theories can underpin the empirical reality of GSCM in construction and connect it to a larger body of knowledge.

2.3.6.2. Gaps pertaining to lack of geographical coverage

As seen in Table 2.5, the other significant gap in the literature is that there is little understanding on parts of the world which have witnessed major construction booms in recent times such as Brazil, Mexico, Saudi Arabia and United Arab Emirates (UAE). The relevance of a GSCM investigation would be much greater for these countries. At present, most studies have primarily focused on developed countries in the UK and US and emerging economies like China, Singapore, and Hong Kong. This study is expected to address this gap to an extent, given that UAE is the country under investigation, although this was not the overarching reason for choosing UAE as the research setting.

The next section will discuss the research setting, the UAE construction sector, including its characteristics, and the rationale for choosing it.

2.4. UAE as the context for investigating GSCM in the construction sector

Having the right research setting is important for any research (Bryman, 2016). After careful consideration, the UAE was selected as the research setting to carry out the investigation. The characteristics of the UAE and its construction sector and the rationale for selecting UAE are discussed in this section.

2.4.1. About UAE

UAE is an Arab country in the Southern part of Arabian Peninsula as shown in Figure 2.2.



Figure 2.2 The map of United Arab Emirates

Fig 2.3 shows the population growth of UAE (World Bank country data of UAE, 2016).

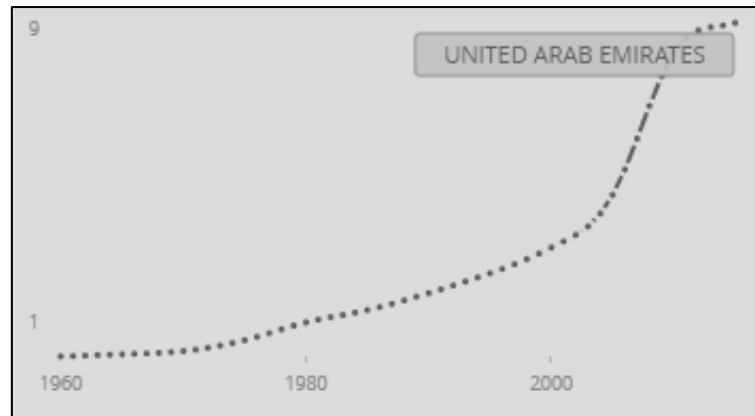


Figure 2.3 Population growth of UAE (Source: World Bank)

According to the statistics, the population of UAE has grown from just over 3 million in 2000 to over 9 million in 2016. This significant increase in the population, as shown in figure 2.3, is putting pressure on the construction sector to meet the growing needs of its population.

Moreover, because of its stability, positive outlook and growth opportunities, the UAE economy has been able to attract significant foreign direct investments (FDI). According to the Global Investment Report 2017, the UAE stands at 9th position as the largest recipient of foreign direct investment (FDI) in Asia and 1st in the region (UNCTAD, 2017). In 2016 alone, the UAE attracted USD 8.9 billion worth of FDI, an increase of 1.7% from 2015. In addition to its political and economic stability, ease of doing business may be a reason for this increase in foreign direct investment. According to World Bank Group Doing Business report, UAE is placed relatively high at 26th position out of the 192 countries included in the report (WBG, 2017). This is mainly due to the factors such as no direct taxing of firms, no limit in the repatriation of funds, and a strong banking and technological infrastructure. The top two inward FDI countries to the UAE are the UK (23.7%) and US (12.1%) (UAE Bureau of Statistics)¹

While this statistic alone can give a broad understanding of the nature of the foreign firms in the UAE, a closer examination of the Greenfield Investment² statistics of the UAE, which can give a more accurate picture of the nature of foreign subsidiaries operating there, shows that UAE was the leading country by number of Greenfield FDI projects attracted (302 projects worth USD 13 billion) in the Middle East and North Africa (MENA) region (FDI, 2014).

¹ <http://fcsa.gov.ae/en-us>

² A green field investment is a form of foreign direct investment where a parent company builds its operations in a foreign country from the ground up. It does not include mergers and acquisitions or other equity-based or non-equity investments

2.4.2. The UAE construction sector

The UAE construction sector, which witnessed an unprecedented construction boom in the last decade or so, has played a key role in changing the landscape of the UAE economy to a modernised economy. For instance, some of the largest construction projects in the world including the tallest structure (Burj Khalifa), the tallest hotel (JW Marriott Marquis), and the largest mall (Dubai Mall) have recently been carried out there. In addition to these tallest and largest, UAE is also home to some of the most innovative and luxurious skyscrapers and man-made islands. The sector, which is growing at more than 9% per year (Zawya, 2015), accounts for roughly 41% of the total construction projects in Gulf Cooperation Council (GCC) countries (Zawya, 2013) and the sector's net worth is estimated to be US\$ 42 billion in 2015 (AI, 2015).

Furthermore, the construction sector is the 2nd biggest recipient of FDI after the financial sector in the UAE (UAE Bureau of Statistics, 2015). The construction sector accounted for 27% of the total greenfield investments in the UAE.

Also, the landscape of the UAE construction sector is competitive. Statistics of market shares according to size shows that 48% of the market share of the UAE construction industry is accounted for by 18 large firms, while the remaining 52% is shared by thousands of small and medium firms in the UAE (Oryx, 2013).

2.4.3. Environmental implications of the UAE construction sector

Not surprisingly, the construction sector growth has caused significant adverse impact on the environment. An estimated 30 million tonnes of construction and demolition (C&D) waste was generated by the UAE construction sector in 2007, higher than that generated in Spain and Netherlands combined (Al-Hajj and Kamani, 2011; Jaillon et al., 2009). This accounts for around 75% of all the solid waste generated in UAE (SCAD, 2013). Moreover, the sector was one of the major contributors of carbon emission in the UAE, resulting in UAE been rated as one of the top carbon emission countries in the world (World Bank, 2016).

2.4.4. Green initiatives in the UAE

However, these adverse environmental impacts have also triggered significant green practice application in line with the UAE's vision to become one of the most sustainable countries by 2021 (Vision, 2021). These significant efforts undertaken by the UAE government and construction firms in recent years have resulted in marked improvements in the

environmental aspects. For instance, the number of green buildings in the country has increased. According to Leadership in Energy and Environmental Design (LEED) 2015 statistics (the world's largest green building rating body), the number of LEED-certified projects in the UAE has increased from few in 2011 to close to one thousand in 2015 (LEED, 2015). Also, the per capita carbon emissions have reduced from 23 in 2008 to 18.3 in 2013, though it is still one of the highest per capita carbon emission countries in the world according to World Bank statistics³. The introduction of green building regulation in Dubai in 2011 and Abu Dhabi in 2010 has ensured 90% of all new buildings in the UAE have to comply with the green building guidelines, a step in the right direction.

In addition, the UAE has also initiated the following initiatives that demonstrate their commitment to environmental protection:

- The UAE has integrated strategies to reduce energy and compact climate change within the framework for its 2021 vision (SGER, 2016).
- In 2016, UAE established a new ministry called Ministry of Climate Change and Environment⁴
- The significant strides achieved by the UAE are evident from some of the international recognition it has received for some of their projects. For instance, the Dubai Electricity and Water Authority building, the largest government building in the world to secure a LEED Platinum rating for green buildings, has opened for business. Similarly, the LEED platinum-certified Change Initiative (TCI) building in Dubai has received the award for the "most sustainable" commercial building in the world⁵.
- Within the UAE, Dubai's target (where buildings use 70% of all energy) is to become one of the top 10 sustainable cities in world by 2020 with targets to cut energy consumption by 20%, water consumption by 15% and GHG emissions by 20% (SGER, 2015).
- Similarly, in Abu Dhabi, Masdar City, when fully completed by 2020 (with a capacity to house around 40,000 people) is expected to become the world's most sustainable low-carbon city and is also a leading centre for sustainable research⁶

³ <http://data.worldbank.org/indicator/EN.ATM.CO2E.PC>

⁴ <http://www.moccae.gov.ae/en/about-ministry/mandate-of-the-ministry.aspx>

⁵ <http://inhabitat.com/leed-platinum-change-initiative-building-in-dubai-declared-the-worlds-most-sustainable-commercial-building/>

⁶ www.masdar.ae

Overall, on the one hand, UAE is driven by the need to meet the growing demands of urbanisation, while on the other, is the need to curtail the adverse environmental impacts of rapid urbanisation. Therefore, the UAE provides a perfect research setting for developing a more comprehensive theoretical and practical understanding of the adverse environmental impacts of the construction sector, as well as for identifying the potential opportunities for lessening the impacts from a GSCM perspective. Finally, firm size and the foreign direct investment statistics in the UAE show that the UAE is an ideal setting to understand the impact of firm size and firm ownership on GSCM.

2.4.5. Summary

To summarise, this chapter began with a brief discussion of the history of GSCM, and how it emerged as an integrated approach to tackling environmental issues from several related but standalone predecessors. Then the significant progress and application witnessed in GSCM across sectors were discussed, including how several authors defined it and looked at it from multiple perspectives. The chapter then discussed the outcomes of the comprehensive (generic) review and content analysis of more than 100 GSCM studies that encapsulated the main scope of GSCM in terms of managerially relevant GSCM themes/sub-themes. Before conducting the review of GSCM studies in construction, the chapter discussed the construction supply chain in terms of its key stakeholders, features, similarities and differences with other sectors. This knowledge of the construction supply chain significantly helped frame the review of GSCM studies in the construction sector. The review of GSCM-related studies in the construction sector was conducted in conjunction with the GSCM studies in other sectors which have seen significant progress and application in line with this study's research objectives to understand the pertinent gaps in the literature and for formulating relevant, precise and demanding research questions and for formulating potential hypothesis (wherever relevant). Finally, the chapter discussed the rationale for choosing the UAE as the exemplary research setting for conducting the investigation.

The next chapter will discuss the methodology adopted to carry out the GSCM investigation in the UAE construction sector.

Chapter 3 - Methodology

The preceding chapter discussed the research gaps and the significance of the research questions proposed in this thesis. This chapter will discuss in detail the overall research process undertaken to answer the research questions including the various methods used, their relevant explanation and justification within the broader context of alternative methods available.

First, the chapter discusses the philosophical approaches and methods in general and those used in previous green supply chain research. The philosophical stance of this thesis is discussed next, followed by the research design adopted in this study to answer the research questions. Finally, the different methods including the techniques used for data analysis are explained.

3.1. Research Philosophies and Paradigms

Meaningful and productive research requires a sound and relevant research philosophy. Otherwise, research rarely leads to more than simply confirming what is already known (Arbnor and Bjerke, 1997). Research philosophy can be referred to as an overarching term that relates to the development of knowledge and the nature of that knowledge with regards to particular research (Saunders et. al., 2016). Especially in business and management, researchers need to be aware of the philosophical commitments that they make in the choice of research strategy since it will have a significant impact on what they do, and how they understand what it is they are investigating (Johnson and Clark, 2006). It comprises critical assumptions about how the researcher views the world. According to Saunders et al. (2016), these views/assumptions determine the way in which research is conducted such as the research strategies, design and methods used. However, before deciding on the philosophical stance of this thesis, it is important first to recognise the disagreements that exist between different philosophical assumptions (Saunders et al., 2016). Epistemology and Ontology are two distinct philosophical assumptions that are most often used in the social science context (Saunders et al., 2016; Bryman, 2016).

Epistemology is concerned with a researcher's view regarding what constitutes acceptable, valid and legitimate knowledge in the discipline, and how the knowledge is communicated to others and how it is used to address particular social concerns (Bryman and Bell, 2015;

Bryman, 2016; Saunders et al., 2016). In the multidisciplinary context of business and management, the different types of knowledge could range from numerical data to textual and visual data, from facts to interpretations, and narratives and stories (Saunders et al., 2016).

Ontology, on the other hand, is concerned with a researcher's view of the "nature of reality" or the "nature of knowledge" (Guba, 1990). Ontological assumptions shape the way in which the researcher sees and studies research objects (Saunders et al., 2016). In business and management, these research objects are social entities that include organisations, management, individuals and artefacts (Bryman, 2016).

These philosophical positions can be represented as a research paradigm. A paradigm is a cluster of beliefs and dictates which for scientists in a particular discipline influence what should be studied, how research should be done, and how results should be interpreted (Bryman, 1988). Three important paradigms that are commonly adopted in business research are positivism, interpretivism and pragmatism (Creswell, 2013; Saunders et al., 2016; Bryman and Bell, 2015).

Positivism entails a belief based on the assumption that patterns (trends), generalisations, methods, procedures, cause-and-effect issues are also applicable to the social sciences. Therefore, positivism encourages the use of natural sciences methods in management research which can be confirmed by the senses, measured and generalised (Denscombe, 2008). In other words, social science investigation is conducted in a similar way to natural sciences (Bryman, 2016). Moreover, the view of positivism maintains that the objects of the social sciences, namely people, are suitable for the implementation of scientific methods (Denscombe, 2010; Lincoln et al., 2011). The positivist researcher, therefore, prefers working with an observable social reality; and such research would produce generalisations similar to those produced by natural scientists (Welman et al., 2015). Quantitative research methods, therefore, are considered to be positivist in approach, characterised by a numerical orientation and emphasis on the measurement and analysis of causal relationships (Saunders et al., 2016).

On the contrary, interpretivism is the opposite of positivism. Interpretivism emphasises that humans are different from physical phenomena because they create meanings (Saunders et al., 2016). Therefore, it holds the view that the social world cannot be understood by applying

research principles adopted from the natural sciences (Gephart, 1999). That is, simple fundamental laws cannot explain the complexity of social phenomena (Blumberg et al., 2014). In short, natural science is concerned with experimental matter, while social science is concerned with the subject matter (Bryman, 2016). In this view, the reality is not considered external to the actors but a part of the subjective interpretation of the actors themselves (Blumberg et al., 2014). That is, reality should rather be interpreted through the meanings that people give to their life world (Schwandt, 2014). Gephart (1999) mentions that interpretivistic views tend to show a preference for methods which do not only produce facts but analyse and describe the meaning of the social world (situation). Therefore, qualitative research methods such as interviews, case studies and focus groups, used to understand the world from a subjective position (Saunders et al., 2009), are considered as the interpretivist view, where there is greater emphasis on human behaviour and its role in the research context.

Pragmatism emerged from the paradigm war of positivism versus interpretivism (Tashakkori and Teddlie, 1998). It is considered as the "third wave" or third research movement, a movement that goes beyond the paradigm wars between qualitative and quantitative research by offering a logical and practical alternative (Johnson and Onwuegbuzie, 2004). For pragmatists, reality matters as practical effects of ideas, and knowledge is valued for enabling actions to be carried out successfully (Saunders et al., 2016). Hence for pragmatists, either a positivist or interpretivist approach may not be sufficient to understand a problem (Morgan, 2014) but they acknowledge the fact that both qualitative and quantitative approaches have intrinsic strengths and weaknesses and researchers, therefore, should utilise the strengths of both approaches to better understand the social phenomenon (Sieber, 1973). For example, quantitative methods can test theories, but cannot generate them. Pragmatists link the choice of approach directly to the purpose of and the nature of the research questions posed (Creswell 2013). Research is often multi-purpose, and a "what works" tactic will allow the researcher to address questions that do not sit comfortably within a wholly quantitative or qualitative approach to design and methodology. Pragmatists typically consider a multi-method strategy or mixed research methods, which combines qualitative and quantitative methods/strategies in a simultaneous or sequential manner using methods in a fashion that best addresses the research question(s) (Creswell 2013).

Table 3.1 summarises the connection between different philosophical stances and paradigms. From the table, it could be inferred that each research philosophy and paradigm has its own advantages and disadvantages and therefore it is not logical to assume that one research philosophy or paradigm is better than the other; instead, selecting a research philosophy and paradigm should depend on the research question that the researcher seeks to answer (Saunders et al., 2016). Since each research philosophy and paradigm has appreciable differences which could affect the way in which research is conducted, from a researcher's perspective, it is important to defend/justify their choices in relation to the alternatives they could have used (Johnson and Clark, 2006).

Table 3.1 Main research philosophies and paradigms in business and management research

Paradigm \ Philosophy	Positivism	Interpretivism	Pragmatism
<i>Epistemology</i> : the researcher's view regarding what constitutes acceptable knowledge	<ul style="list-style-type: none"> •Scientific method •Observable and measurable facts •Law-like generalizations •Numbers •Causal explanation and prediction as contribution 	<ul style="list-style-type: none"> •Theories and concepts too simplistic •Focus on narratives, stories, perception and interpretations •New understanding and world views as contribution 	<ul style="list-style-type: none"> •Practical meaning of knowledge in specific contexts •'True' theories and knowledge are those that enable successful action •Focus on problems, practices and relevance •Problem-solving and informed future practice as contribution
<i>Ontology</i> : the researcher's view of the nature of reality or being	<ul style="list-style-type: none"> •Real, external, independent •On true reality (universalism) •Granular (things) •Ordered 	<ul style="list-style-type: none"> •Complex, rich and external •Socially constructed through culture and language •Multiple meanings, interpretations, realities •Flux of processes experiences, practices 	<ul style="list-style-type: none"> •Complex, rich and external •'Reality' is the practical consequences of ideas •Flux of processes experience and practices

Saunders et al. (2016)

However, before deciding on the appropriate research philosophy and paradigm to effectively answer the research questions, the nature of research in previous GSCM studies should be

critically evaluated to guide in making the right choice for this research. The next section discusses the nature of research in previous GSCM studies.

3.2. Nature of research in green supply chain management

Table 3.2 shows the nature of research in green supply chain management based on the studies of Seuring and Muller (2008) and Malviya and Kant (2015). The timeline of these studies also enabled us to understand how the nature of research is evolving in GSCM.

Table 3.2 Research methods applied in green supply chain management research

Methods used	Seuring and Muller (2008)	Malviya and Kant (2015)
Quantitative – Survey	28%	31%
Quantitative - Mathematical Modeling/Simulation	11%	15%
Qualitative - Case Studies/Interviews/Focus groups	37%	23%
Conceptual/Literature review (non-empirical)	24%	9%
Qualitative + Quantitative (eg: survey + interviews, case studies + mathematical model etc.)	Stats not included	24%
	100%	100%

It is evident from the table that there are no dominant paradigms in GSCM research. Both quantitative (positivistic) and qualitative (interpretivist) approaches are found. For instance, the literature survey of 191 articles by Seuring and Muller (2008) shows 39% quantitative, 37% qualitative and 24% conceptual/theory building and literature studies. The relatively high percentage (24%) of conceptual/theory building papers is not surprising given that GSCM was a relatively new field in 2008 compared to 9% conceptual/theory building papers in the literature survey of 177 articles conducted by Malviya and Kant (2015). The increase in the positivist stance (46%) in Malviya and Kant (2015) vis-à-vis 39% in Seuring and Muller (2008) is also not surprising given that researchers are now moving towards testing theories already developed. However, the interesting aspect of the table is the fact that 24% of studies reported in Malviya and Kant (2015) used a combination of qualitative and quantitative research (a pragmatic approach). Though this statistic was not reported in Seuring and Muller (2008), it could be argued that there is a recent paradigm shift towards mixed research methods, since a closer evaluation revealed that it is the most recent studies that have used mixed methods. Pragmatism is generally regarded as the philosophical partner for mixed research methods (Denscombe, 2008). Moreover, the philosophical assumption of these studies is more epistemological than ontological. This is because studies in GSCM are more

concerned with validating, extending and communicating the knowledge using different types of knowledge sources. There is less need to make an ontological assumption regarding the nature of reality given that the environmental concerns facing the world such as global warming, rising sea levels and natural resources are happening and it is real.

3.3. Philosophical stance of this thesis

The nature of the research in previous studies and the nature of the research questions posited in this study determined the philosophical stance of this thesis. An epistemological position and a pragmatic approach to research are considered in this thesis. The reason for choosing an epistemological position is because this study is attempting to extend the knowledge of GSCM in the construction sector and in general to curtail the adverse environmental implications of the construction sector. The pragmatic approach is chosen because it is necessary to act fast as the clock is ticking to combat environmental issues, and for that practical and realistic solutions are needed to inform practice, i.e., the practical application of GSCM in the construction sector. A comprehensive understanding of both theoretical and practical issues in most cases requires integration of both qualitative and quantitative methods in a single study (Newman and Benz, 1998). This could well explain the recent trend in the literature as seen in Table 3.2. Also, the nature of the research questions proposed in this study such as ‘what’, ‘why’, ‘how’, ‘how much’ and ‘to what extent’ mandates the use of both qualitative and quantitative methods. For example, some aspects of the research question such as ‘to what extent’ are better understood through quantitative collection and analysis of a large amount of data from a sizable population, whereas exploratory and explanatory aspects of the research such as ‘what’ and ‘how’ questions respectively require detailed qualitative information with greater emphasis on human behavior and its role in the research context to explain the social phenomenon (Yin, 2003; Saunders et al., 2016). Therefore, on both counts, pragmatism seems to be the right approach for conducting the research envisioned in this thesis. The next section discusses in detail the research design this thesis adopted.

3.4. Research design

The research design is the overall plan of how the researcher will go about answering the research questions (Saunders et al., 2016). It will contain a framework for the collection and analysis of data (Bryman, 2016). A choice of a research design reflects decisions about the

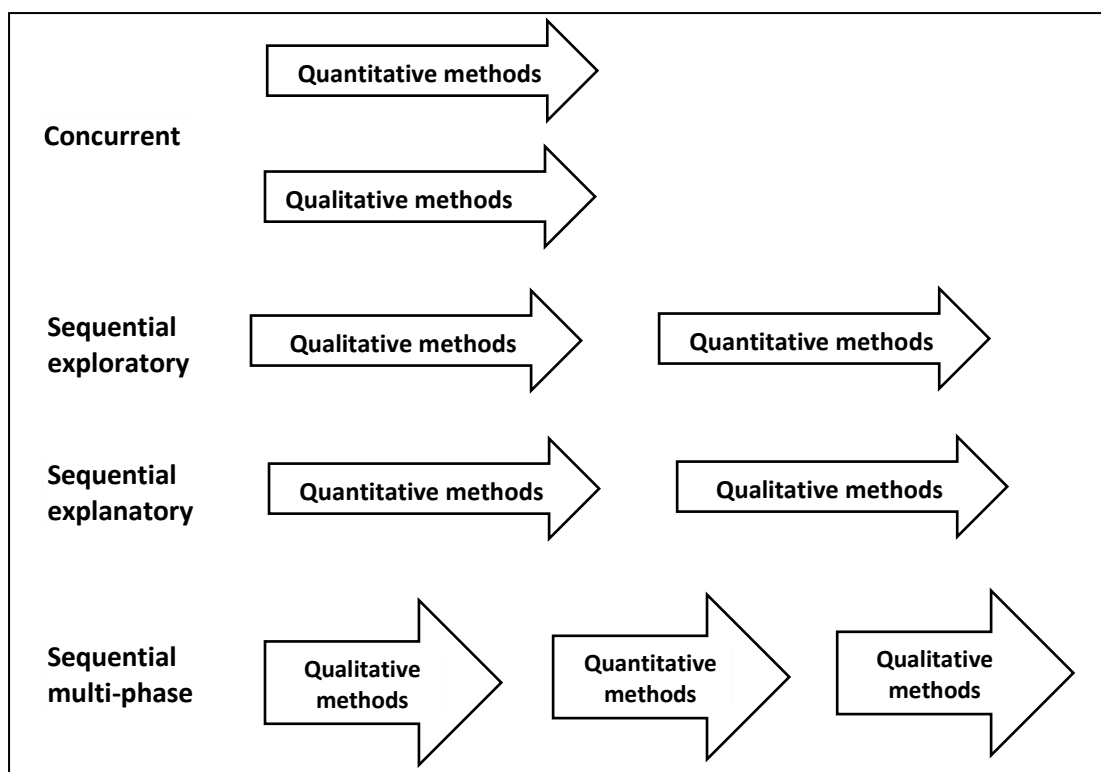
priority being given to a range of dimensions of the research process (Bryman, 2016). In other words, the research design articulates what data is required, what are the data sources, what methods are going to be used to collect and analyse the data, and how all of this is going to answer your research question(s) (van Wyk, 2012). It gives the researcher an opportunity for building, revising and choreographing the overall research study to maximise the validity of the eventual results (Miles and Huberman, 1994, Mouton, 1996).

The first methodological choice in a research design is to decide on whether to follow a qualitative, quantitative or mixed methods design (Saunders et al., 2016). This decision should be in coherence with the research questions and must fit with the research philosophy (Saunders et al., 2016). Table 3.3 summarises the research questions proposed in chapter 2.

Table 3.3 Summary of research questions proposed in this thesis

Research questions	
RQ1	What core and facilitating green practices are implemented by individual construction sector stakeholders and the extents of their implementation?
RQ2	What are the green drivers and barriers (external and internal) for implementing green practices (core and facilitating) for individual construction sector stakeholders and their perceived importance/relevance?
RQ3	What green performance measures (in environmental, cost/economic and organisational terms) are used by individual construction sector stakeholders and the extents of improvement in them from implementing green practices (core and facilitating)?
RQ4	How and to what extent do green drivers and barriers (external and internal) impact green practices (core and facilitating) for individual construction sector stakeholders? <i>(at the strategic level and at the operational/implementation level)</i>
RQ5	How and to what extent do green practices (core and facilitating) impact green performance (environmental, cost/economic and organisational) for individual construction sector stakeholders? <i>(at the strategic level and at the operational/implementation level)</i>
RQ6	How and to what extent do facilitating green practices impact core green practices for individual construction sector stakeholders? <i>(at the strategic level and at the operational/implementation level)</i>
RQ7	How and to what extent do firm size and firm ownership impact GSCM themes/sub-themes in the construction sector?

The nature of the research questions and the pragmatic stance of this thesis warrant the use of mixed research methods, i.e. combining both qualitative and quantitative methods in one study. However, there are different ways to integrate both qualitative and quantitative methods in mixed research design. Figure 3.1 shows the most common approaches to mixed research design.



Source: Saunders et al. (2016)

Figure 3.1 Mixed methods research designs

As seen in the figure, in concurrent mixed methods research, qualitative and quantitative data collection and analysis occur concurrently. It allows both sets of results to be interpreted together. However, in sequential mixed methods design, one method (qualitative or quantitative) of data collection and analysis will follow the other method (qualitative or quantitative) of data collection and analysis. As seen in the figure, based on the sequence, sequential methods can be characterised as sequential exploratory (qualitative followed by quantitative) and sequential explanatory (quantitative followed by qualitative). Lastly, in sequential multi-phase, multiple stages of data collection and analysis are involved, one after the other.

As stated, a pragmatic approach is being followed in this thesis, and therefore the nature of the research questions is driving the mixed methods design. This implies making decisions about which kinds of research question or parts of research question are best answered using qualitative research methods and which by quantitative research methods (Bryman, 2016). As seen in Table 3.3, the nature of the research questions warrants the use of sequential exploratory mixed methods design, that is collection and analysis of qualitative data prior to the collection and analysis of quantitative data. For instance, the first part of the proposed

research questions such as “What are.....”, and “How do.....” warrants the use of qualitative methods prior to the use of quantitative methods for answering the second part of the proposed research questions such as “extends of.....” and “perceived importance/relevance.....”.

Now that the sequential exploratory research design has been selected, the next stage is to decide on the choice of methods. A research method is simply a technique for collecting data (Bryman, 2016). It focuses on the individual steps in the research process and the most ‘objective’ (unbiased) procedures to be employed within the wider context of alternative methods (van Wyk, 2012). For example, it can involve a specific instrument such as an interview protocol or self-administrative questionnaire to collect and analyse data in qualitative and quantitative stages. Figure 3.2 illustrates the sequential exploratory research design adopted in this thesis including the different methods used to collect and analyse data. As seen in figure 3.2, a comprehensive review and critical interpretation of the literature was carried out first to define the GSCM themes/sub-themes and to formulate the important research questions based on the pertinent gaps in the literature (already discussed in chapter 2). With regards to the qualitative phase, as seen in the figure, the qualitative data was collected using interviews, which were conducted in two phases.

In phase 1, semi-structured exploratory interviews were carried out to explore and define each GSCM themes/sub-themes identified in the literature. The collected data were analysed and categorised as per the GSCM themes and sub-themes. The phase 1 interviews were an important part of this research because they contributed to the overall research in multiple ways. Firstly, the descriptive findings of the phase 1 interviews largely contributed to answering the first part (“What”) of the research questions RQ1 to RQ3 (refer to Table 3.3). Secondly, they helped to understand better the causal relationships between GSCM sub-themes at the operational/implementation level (later stage) since they relied on how well these GSCM themes/sub-themes and factors were captured in the first place using phase 1 interviews. Lastly, the phase 1 interview findings were the main contributor in the development of survey instrument (quantitative phase). The objective of phase 2 interviews was mainly to understand the causal relationships between GSCM themes/sub-themes at the operational/implementation level. Here, though, the objective warrants the use of more

focused, in-depth interviews. This phase contributes to answering RQ4 to RQ6 at the operational/implementation level.

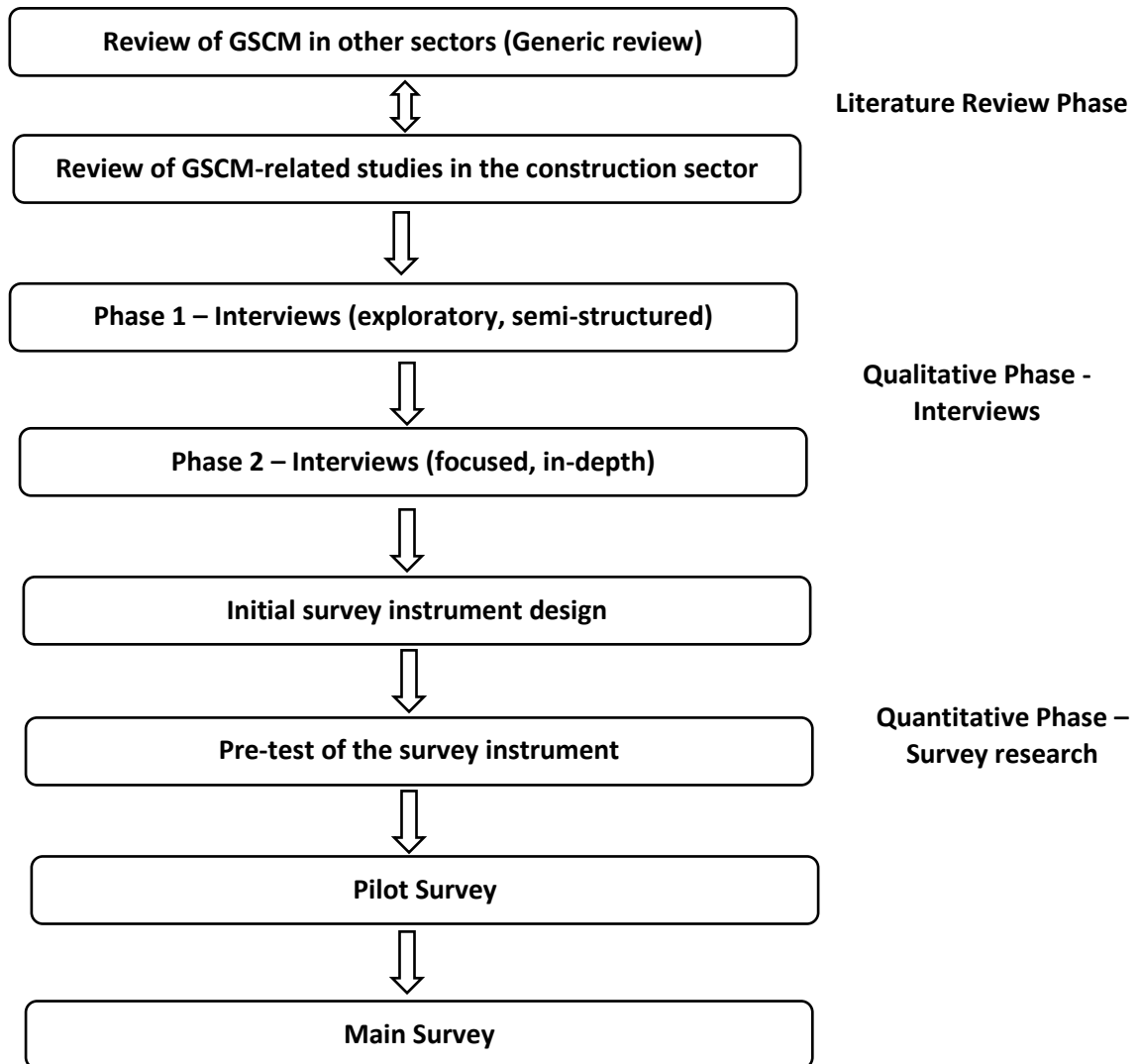


Figure 3.2 Research design used in this thesis

As seen in the figure, the data collection for the quantitative phase of the research was carried out using survey research. The second part of the research questions such as “extents of” or “perceived importance/relevance” (RQ1 to RQ3), strength of the causal relationships at the strategic level (including testing hypotheses) (RQ4 to RQ6), and extent of influence of firm size and firm ownership on GSCM aspects (RQ7) is answered using data collected through survey research. The ability of the survey to obtain large scale data implies that the generalisability of the findings can be extended to a larger population.

Overall, the advantage of this research design is that it offers “completeness”. Completeness implies that the gaps left by one method are filled by the other (Bryman, 2016). In this thesis, all the different stages of the research and methods used have contributed to varying degrees to provide a complete answer to each of the proposed research questions. For instance, both phase 1 and phase 2 interviews complemented each other well; that is, one dominant method type is enhanced or clarified by the results from another method type (Cameron, 2009). For instance, some of the findings from phase 2 interviews helped in clarifying some of the ambiguities in phase 1 interviews with regard to the GSCM themes/sub-themes and factors. Conversely, some of the phase 1 findings also provided support/clarity in understanding the causal relationships between GSCM sub-themes at the factor level. In addition, qualitative findings (phase 1 and phase 2) facilitated/enhanced the survey instrument used in the quantitative investigations. Further, they helped reason the quantitative findings obtained later in the study.

In the following sections, the approach/methods adopted at different stages of the research, namely literature review, qualitative phase and quantitative phase are explained in detail, including methods used to collect data and techniques used to analyse data in each stage. First, the steps entailing the literature review process are explained.

3.5 Literature review process

Reviewing the existing literature is important because it is the starting point as well as the foundation of most research (Saunders et al., 2002). According to Bryman (2016), the literature review process is an examination of the current state of theory and research relating to the researcher’s field of interest that outlines what is already known/unknown and that frames and justifies the research questions. Hence, it acts as a background to what you want to research and provides a platform for establishing what the contribution of your research will be. In this thesis, the literature review was conducted in two phases. In the first phase, a critical assessment of GSCM studies across all sectors (referred to as generic review) was carried out. In the second phase, a critical assessment of green-related studies in construction that looked at relevant aspects of GSCM (referred to as GSCM-related) was conducted.

In the first phase, the study conducted a comprehensive review of existing literature in GSCM to conceptualise its main themes, sub-themes and their interrelationships. This

conceptualization was important because, despite the significant progress, there was an apparent lack of consensus on the scope of GSCM and what it meant.

The literature search process in the first stage entailed the following steps:

- i) Main library databases such as Scopus, ProQuest, EBSCO, Science Direct, Emerald and Elsevier, Taylor and Francis, Springer and Wiley Interscience were used to ensure comprehensive coverage of the literature. The main keywords used for the search include 'green supply chain(s)/ green supply chain management', 'sustainable supply chain(s)/ sustainable supply chain management', 'environmental supply chain management', 'supply chain environmental management', 'green/ environmental/ eco-logistics', and 'closed loop supply chains'.
- ii) Internet search engines such as Google and Google Scholar were used to discover and access the relevant books, industry reports, working papers and presentations.
- iii) Periodic access and review of leading journals that have frequently published articles in GSCM such as *'Journal of Cleaner Production'*, *'International Journal of Production Economics'*, *'Supply Chain Management: An International Journal'*, *'International Journal of Production Research'*, *'Business Strategy and the Environment'*, *'Benchmarking: An International Journal'*, *'Resources, Conservation and Recycling'*, *'Transportation Research Part E'*, *'International Journal of Logistics Systems and Management'* and *'European Journal of Operational Research'* were conducted so as to include the most relevant and up-to-date studies which could have been missed in the keyword search.
- iv) Tracking back references

The initial search process in 2012 in leading databases returned more than 250 scholarly articles. A preliminary refinement of the articles based on the title and abstract analysis enabled the narrowing of the list to around 100 articles to build on. However, the refined list was periodically updated to include the latest publications. A content analysis of these articles enabled the study to conceptualise GSCM and its role in greening a sector/industry. In the process, the review also came across five literature review studies on GSCM. These five review studies, as shown in Table 3.4, have also suggestively helped in the conceptualization of GSCM.

In summary, after the first phase of review, the study was able to conceptualize the key GSCM themes, sub-themes, their relationships, organizational characteristics (size and ownership) that influence GSCM, theories used in GSCM, application of GSCM across different sectors and importantly the maturation of GSCM as a field of practice and an academic domain.

Since the generic review only identified one study in GSCM which has relevance to construction, in the second phase an extensive review of green-related studies that explored the relevant, but isolated aspects of GSCM in the construction sector was carried out. The knowledge gained from first phase helped in the second phase of the literature search process as well as in delineating the relevant gaps in the GSCM literature in construction.

Table 3.4: Summary of previous literature reviews on GSCM

Source	Title	Aim/Focus
Srivastava (2007)	Green supply-chain management: a state-of-the-art literature review	It discusses the opportunities and challenges to practitioners, to look at GSCM from a wider, integrated perspective
Sarkis et al. (2011)	An organisational theoretic review of green supply chain management literature	The study identifies nine broad important organisational theories for application in GSCM
Min and Kim (2012)	Green supply chain research: the past, present and future	This paper describes the past development and current state of GSCM research, synthesises the focused areas of GSCM research, captures the emerging perspectives of GSCM research, and points the directions for future research opportunities
Ahi and Searcy (2013)	A Comparative Literature Analysis of Definitions for Green and Sustainable Supply Chain Management	A total of 22 unique definitions for GSCM were identified and suggested the need for convergence in the scope of GSCM
Malviya and Kant (2015)	Green supply chain management (GSCM): a structured literature review and research implications	A systematic literature review that identifies several research issues in GSCM

The literature search process in the second stage entailed the following steps:

- i) Main library databases such as Scopus, ProQuest, EBSCO, Science Direct, Emerald and Elsevier, Taylor and Francis, Springer and Wiley Interscience were used to ensure comprehensive coverage of the literature. Given the limited studies,

several keywords were used. Some of the indicative keywords used for the search included 'green/ sustainable construction', 'sustainability in construction supply chain', 'green/ sustainable/ environmental practices in construction', 'drivers/ enablers of green/ sustainable/ environmental practices in construction', 'barriers/ challenges of green/ sustainable/ environmental practices in construction', 'environmental/ sustainability/ green performance (measures) in construction', 'green building design', 'green/ environmental/ sustainable purchasing/ procurement in construction', 'green/ environmental/ sustainable transportation in construction', 'end of life management in construction', 'waste management/reduction/ re-use/ re-cycle in construction', 'environmental management systems (EMS) in construction', 'ISO 14001 in construction' and 'green/sustainable buildings'.

- ii) Internet search engines such as Google and Google Scholar were used to discover and access the relevant books, industry reports, working papers and presentations.
- iii) Periodic access and review of leading journals that have frequently published green-related studies in construction such as 'Waste Management', 'Ecological Indicators', 'Habitat International', 'Journal of Cleaner Production', 'Journal of Environmental Management', 'Building and Environment', 'Resources, Conservation and Recycling', 'Automation in Construction', 'Construction and Building Materials', 'Engineering Sustainability' and 'Construction Management and Economics' were conducted so as to include the most relevant and up-to-date studies which could have been missed in the keyword search.
- iv) Tracking back references

Though the initial search produced 100+ articles, most were technical papers. These technical studies were excluded along with some very generic studies. A close evaluation enabled the narrowing of the list (refer Chapter 2, Table 2.2). An in-depth content analysis of these studies allowed us the classification and comparison of the literature findings with respect to the generic GSCM findings obtained in phase 1. This, in fact, qualified the comprehension of the current state of GSCM knowledge in the construction and helped delineate the relevant gaps

in the sector leading to the proposed research questions. Next, details of the qualitative phase, that is how the data was collected and analysed is discussed.

3.6 Interviews

Interviews are the most widely used method in qualitative research (Bryman, 2016). Though there are different methods available for a qualitative study such as observation, interviewing, focus groups and case studies, with each having its own advantages and disadvantages, interviews are best suited when there is an exploratory or explanatory element to the research (Pojasek, 2005). Given the exploratory and explanatory nature of the proposed questions in this thesis, interviews were chosen as the method to capture the qualitative aspects of this study. The following section will discuss how interviews were conducted and analysed in each phase.

3.6.1 Interviews (Phase 1)

As stated earlier, given the limited understanding of GSCM in the construction sector, the objective of this phase was to explore and define the underlying factors within each GSCM theme/sub-theme, namely green drivers (external and internal), green barriers (external and internal), green practices (core and facilitating) and green performance (environmental, cost/economic and organizational) across all key stakeholders in the construction sector. This was an important phase of the research as it not only contributed directly in answering the first part of the research questions RQ1 to RQ3, it also laid a solid foundation for the rest of the study to build on.

3.6.1.1. *Structure of the interviews*

As shown in Figure 3.2, the information in this phase was gathered through semi-structured interviews (Miles and Huberman, 1994). In a semi-structured interview, the researcher has a list of questions or specific topics to be covered, often referred to as an interview protocol, but the interviewee has a great deal of leeway in how to reply (Bryman, 2016). Though questions may not follow on exactly in the way outlined in the schedule, or the researcher may ask additional questions, but, by and large, all of the questions will be asked from interviewee to interviewee. In this study, this approach was preferred because the scope of the interviews (in line with the research objectives) revolved around four main aspects, namely: green drivers, green barriers, green practices and green performance. Therefore, it enabled easy comparison of responses vis-a-vis the alternative unstructured interviews,

which are susceptible to information overloading (Weller and Romney, 1988; Kvale, 2007) and provided more flexibility to explore new aspects within the main ones than the typical structured interviews, where the researcher is most likely to read out the predetermined and standardized question and then record the responses on a standardised schedule, usually with pre-coded answers (Saunders et al., 2016). Studies by Kvale (2007) and Rabionet (2011) were used as a basis to establish the ethical guidelines and the interview protocol. The detailed interview protocol used in this study is given in Appendix A.

3.6.1.2. Sampling approach used

Once the nature of the interviews is chosen, the next important aspect is to decide on the sampling approach. As Bryman (2016) suggests, there are two approaches to sampling in qualitative research, namely probability and non-probability or random sampling, and the selection should be based on the nature of the answers being sought in answering the research questions. In this thesis, it was not possible to recruit any construction industry professional at random for interviewing; instead it was necessary to be selective in recruiting professionals so that they represented all the key stakeholders in the supply chain (i.e. Developers, Architects/Consultants, Contractors and Suppliers) as well as the extended stakeholders (End consumers/buyers, real estate agents, non-government organizations and regulatory bodies). Therefore, purposive or selecting sampling, a form of non-probability sampling was chosen. The goal of purposive sampling is to sample cases/participants strategically so that those sampled are relevant to the research questions that are posed. In the phase 1 interviews, in addition to their stakeholder status, the designation and experience of the interviewees were the main qualifying factors in the recruitment of participants.

In terms of the strategy used to recruit participants, a sequential sampling strategy was used (Teddlie and Yu, 2007). In this strategy, sampling is an evolving process in which the researcher usually begins with an initial sample and gradually adds to the sample till the goals of the research are met. First, based on the qualifying criteria, more than 200 potential participants (Managers/Senior Managers with green knowledge/responsibility in their respective organizations) across all stakeholders (Developers, Architects'/Consultants, Contractors and Suppliers) from the Zawya database⁷ (paid online database) were contacted

⁷ https://www.zawya.com/uae/en/company/Pro_Business_Directory-13010586/

by email with a brief description of the intended study. Out of which, the 12 respondents who agreed to participate were interviewed. Further interviews were conducted using snowball technique. The advantage with snowballing techniques is that it makes use of participants as referral sources. Participants recommend others they know who may be eligible (Luborsky and Rubinstein, 1995). From the potential snowball participants, priority was given to contact first those participants who represented different stakeholders and belonged to firms with different characteristics (size and ownership). In this way, a reasonable representation of participants was obtained from firms of different sizes and ownership. Also, for Suppliers, concerted efforts were taken to include the main material Suppliers (the most consumed) in the construction project such as cement, glass, steel and aluminium.

With regards to the number of interviews to be conducted in an exploratory study, though there is no “gold standard” that will calculate the number of people to interview (Luborsky and Rubinstein, 1995), the rule of thumb is to achieve saturation (Baker and Edwards, 2016). In this phase, given the constraints of time and cost, the interview process was continued until a reasonable level of saturation was achieved in the responses within each category, i.e. within each GSCM themes/sub-themes. Theoretical saturation implies that there is no need to continue with data collection in relation to a category or cluster of categories; instead, the researcher should move on with the other objectives of the research such as testing of the hypotheses (Bryman, 2016). Overall, a total of 37 interviews were conducted across different stakeholders in the UAE’s construction sector over a six-month period. The demographic details of the interviews are given in Table 3.5.

3.6.1.3. Classification of respondents based on demographics

Though there is no unified, UAE-wide definition for small, medium and large firms (Khalifa Fund, 2016), the study followed the Dubai government’s definition for categorising firms based on size to categorise respondents as shown in Table 3.5. According to the Dubai government, any services or manufacturing organisation falls under ‘small firm’ category if the number of employees is between 20 and 100; ‘medium firm’ category if the number of employees is greater than 100 but less than or equal to 250; and large firm category if the number of employees is greater than 250 (SME, 2013). Categorisation of ownership is based on whether the firm is locally owned or foreign owned. In the case of joint ventures and

Table 3.5 Demographic details of respondents (Phase 1 – Interviews)

Stakeholders	Size	Annual Revenues	Majority Ownership	Interviewee/s
<i>Supply chain stakeholders</i>				
Developer 1	Small	~\$500 million	Local	Environmental Analyst, Manager (Community Development)
Developer 2	Medium	~\$900 million	Local	Environmental Manager, Manager (Waste), Head of Projects
Developer 3	Large	~\$2 billion	Local	Senior Manager (Planning & Sustainability)
Architect/Consultant 1	Small	~\$30 million	Foreign	Sustainability Specialist, Senior Architect
Architect/Consultant 2	Medium	~\$150 million	Foreign	Head of Sustainability
Architect/Consultant 3	Large	~\$600 million	Foreign	Senior Consultant
Architect/Consultant 4	Small	~\$50 million	Local	Consultant (Environment and Sustainability)
Architect/Consultant 5	Medium	~\$200 million	Local	Senior LEED Consultant
Architect/Consultant 6	Large	~\$500 million	Local	Director (Projects)
Main contractor/subcontractor 1	Small	~\$90 million	Local	General Manager
Main contractor/subcontractor 2	Medium	~\$450 million	Local	Senior Project Manager
Main contractor/subcontractor 3	Large	~\$800 million	Local	Senior Manager (Tender), Manager (Business Development)
Main contractor/subcontractor 4	Small	~\$75 million	Foreign	Technical Manager
Main contractor/subcontractor 5	Medium	~\$300 million	Foreign	Project Manager
Main contractor/subcontractor 6	Large	~\$550 million	Foreign	Sustainability Manager, Purchase Manager
Supplier 1 (Cement)	Small	~\$20 million	Local	Senior Manager (HSE)
Supplier 2 (Steel)	Medium	~\$125 million	Local	Production Head
Supplier 3 (Aluminium)	Large	~\$2.3 billion	Local	Procurement Manager, Head of Quality, Head of Manufacturing, Manager (Quality and Production)
Supplier 4 (Gypsum, Cladding)	Small	~\$25 million	Foreign	Production Manager
Supplier 5 (Cement)	Medium	~\$150 million	Foreign	Operations Manager
Supplier 6 (Glass)	Large	~\$800 million	Foreign	Senior QC Engineer, Head (Product Design)
<i>Extended stakeholders</i>				
Government regulatory body (Dubai)	-	-	-	Senior Manager- Dubai Municipality
Government regulatory body (Abu Dhabi)	-	-	-	Senior Manager – ESTIDAMA department
End-user (Tenant)	-	-	-	Tenant, who has been living for four years in a LEED gold certified building
End-user (Owner)	-	-	-	Owner, who has been living for two years in a LEED silver certified building
Real-estate	-	-	-	Handled sales and lease of green buildings including LEED certified.
Non-government organization (NGO)	-	-	-	Vice-Chairman (responsible for promoting sustainability in construction sector)

Note: Very few foreign Developers are operative in UAE (Zawya, 2016), these are therefore not covered

partnerships, the firms were categorised as either foreign or local depending on who has the majority ownership in profits.

3.6.1.4. Data collection process

Regarding the data collection process, all interviews were conducted face-to-face at the office of the respondents, though follow-up interviews for clarifications were carried out over the phone. Each interview lasted approximately 45 to 60 minutes. Most interviews were digitally recorded, and where this was not possible, detailed notes were taken that were later transcribed within one to two days and were also crosschecked with respondents to ensure accuracy. Further, wherever accessible, company documents including annual reports, newsletters, tender documents, internal performance/audit reports, and departmental publications were also sought to complement the interview findings. With regards to the kinds of questions asked, similar questions were posed to all interviewees as per the interview protocol. As seen in the protocol (refer Appendix A), questions were of the nature of 'what', 'how' and 'why' to understand the GSCM themes, namely, green practices, green drivers, green barriers, and green performance.

For instance, with regards to green practices, the respondents (across each stakeholder) were asked to comment on the various green practices they have implemented in their organisation as well their understanding of the general trends (in green practices) across the sector. It also included probing questions such as 'what practices', 'why do you implement', and 'how do you implement'. The respondents were also probed on those green practices from the literature and from the previous interviews in case they failed to mention them.

In regards to green drivers and green barriers, a similar approach to that of green practices was undertaken to identify the relevant drivers and barriers. The respondents were asked to identify the various green drivers and barriers influencing their green practices implementation as well as in general across the sector. This included probing questions such as 'what drivers and barriers', 'how do you react to these drivers and barriers' and 'how much importance do you give to these drivers and barriers'. Again, respondents were probed on those green drivers and barriers identified in the literature and from the previous interviews in case they failed to mention them.

Finally, with regards to green performance measures, interviewees were specifically asked to comment on the relevance/non-relevance of environmental, cost/economic and

organizational performance of their firms from a GSCM perspective; if relevant, they were asked to comment on the specific performance measures (such as reduction in carbon emissions, reduction in material costs, increase in market share) they deemed important across environmental, cost/economic and organisational performance dimensions. Also, accessible company documentation was used to complement the interview findings.

3.6.1.5. *Analysing the data*

With regard to data analysis, the first stage involved thematic analysis of data for each stakeholder. The data drawn from the different interview transcripts and supporting company documentation across the four broad themes (green drivers, green barriers, green practices and green performance) were categorized into nine pre-identified sub-themes from the literature, namely external and internal drivers (1, 2), external and internal barriers (3, 4), core and facilitating green practices (5, 6), environmental, cost/economic and organizational performance (7, 8, 9). Codes were assigned to individual aspects (factors) identified within these sub-themes. For example, government regulation, identified as a driver of green practices, was assigned a specific code within sub-theme 1 (external drivers). Similarly, environmental commitment, another driver identified, was assigned a specific code within sub-theme 2 (internal drivers). Similarly, all the individual green drivers identified were assigned codes and categorised within sub-themes 1 and 2. The same procedure was repeated for green barriers, green practices and green performance for each stakeholder. Sub-codes were also used in certain cases. For instance, sub-codes were used to identify practices such as provision for natural ventilation, natural lighting, etc. within the green design (coded within the core green practices sub-theme). This process of coding allows linking units of data that refer to the same meaning. The studies in Table 2.5 (see chapter 2) also proved useful in developing the codes and sub-codes. In this way, a comprehensive understanding of the underlying factors and sub-factors for each GSCM theme is obtained and hence answers the first part of research questions RQ1, RQ2 and RQ3. Moreover, the qualitative insights were also segregated by size and ownership. This was then used to complement the findings obtained through other research methods (later stage) to develop a complete picture of the influence of size and ownership (RQ7).

Once a comprehensive understanding on the GSCM themes/sub-themes and underlying factors was developed, the next phase of interviews in this study was aimed at understanding

the nature of the relationships (relevance and strength) between GSCM sub-themes at the implementation level (factor level) in line with the proposed research questions RQ4, RQ5 and RQ6.

The next section discusses the second phase of interviews conducted in this study.

3.6.2 Interviews (Phase 2)

Before exploring the details of the interviews, it is important to justify the rationale for choosing a qualitative, interview-based approach in understanding the causal relationships between GSCM themes at the factor level. Though it could be argued that a quantitative approach would be the most suitable for understanding the cause and effect relationships, the decision on using qualitative interviews was taken because implementation level insights on the causal relationship between GSCM sub-themes at the factor level require more in-depth investigation and multiple perspectives. Bryman (2016) highlighted the rich ability of interviews in relation to the understanding of causality. This is because the intensive nature of interviews enhances the researchers understanding of cause and effect between independent and dependent variables (Bryman, 2016). According to Saunders et al. (2016), because of the explanatory power of the in-depth interviews, researchers are likely to consider in-depth interviews to infer the causal relationships between factors. In the thesis, therefore, focused, in-depth interviews were selected as the preferred option to answer the research questions at the operational/implementation level. Moreover, in any case, it was necessary to know the 'how' and 'why' aspect of the causal relationships between GSCM themes at the factor level, which is not possible with quantitative methods.

3.6.2.1. Structure of the interviews

Compared to phase 1 interviews, data in this phase were gathered using a more structured approach. The reason for using a structured approach was because it was known from the outset the different relationships that needed to be understood. Again, studies by Kvale (2007) and Rabionet (2011) were used as a basis to establish the ethical guidelines and the interview protocol. The detailed interview protocol used in this study is given in Appendix B. As seen in the protocol, the scope of the interviews (in line with our research objectives) revolved around understanding the causal relationships between green drivers, barriers, and practices; between green practices and performance; and between different green practices.

3.6.2.2. Sampling approach used

In this case, a purposive sampling method was used. However, compared to phase 1 interviews, the stringency in purposive sampling was even higher. Unlike phase 1 interviews, here a non-sequential or fixed approach to sampling was used (Teddlie and Yu, 2007). In this approach, samples are more or less fixed from the outset of the research. Organisations were chosen carefully to obtain an equal representation of all stakeholders, i.e. Developers, Architects/Consultants, Contractors/Subcontractors and Suppliers (of material) and to obtain an equal representation of firms based on their size and ownership. One of the advantages of this stringent purposive sampling is that it gives the ability to understand a social phenomenon better as they are gathered from two or more different or extreme situations (Bryman, 2016). In addition, in most cases, multiple respondents were carefully selected within each firm to obtain multiple perspectives. A total of 39 semi-structured interviews with senior professionals (most of them had more than ten years of experience in the construction sector) were conducted across 20 firms over a period of 6 months. The demographic details of the respondents are given in Table 3.6.

3.6.2.3. Classification of respondents based on demographics

As seen in Table 3.6, the interviewed firms were classified into four categories, namely large, small, foreign and local based on the same qualification used in phase 1 interviews. In each category, all supply chain stakeholders interviewed (Developers, Architects/Consultants, Contractors and Suppliers) belonged to that category. For example, in the size category, all stakeholder firms interviewed were large.

3.6.2.4. Data collection process

With regards to the data collection process, again all interviews were conducted face-to-face at the office of the respondents. The questions were asked exactly in the sequence mentioned in the protocol. Each interview lasted approximately 45 to 75 minutes. The majority of the interviews were digitally recorded, and where this was not possible, detailed notes were taken. All the interviews were transcribed within 48-72 hours and were also crosschecked with respondents for accuracy. In select cases, a few interviewees were re-contacted for further clarification. Here also, any available and relevant secondary data were sought to complement the interview findings.

As seen in the interview protocol, the questions posed to the respondents were of the nature

Table 3.6. Demographic details of respondents (Phase 2 – Interviews)

Stakeholders	Interviewee Details	Developer	Architect/ Consultant	Main Contractor	Subcontractor	Supplier
<i>Large</i> (All key stakeholder firms involved are large)	Annual Turnover	~\$ 2.5 billion	~\$ 550 million	~\$ 900 million	~\$ 450 million	~\$ 1.8 billion
	Designation of Interviewee	<ul style="list-style-type: none"> •Head of projects •Director- Sustainability & Commissioning 	<ul style="list-style-type: none"> •Vice President •Senior Architect 	<ul style="list-style-type: none"> • Senior Project Manager • Head of Procurements • Senior Coordinator - Contracts 	<ul style="list-style-type: none"> •Site Engineer •Project Manager 	<ul style="list-style-type: none"> •Divisional Manager •Business Development Manager-MENA •Project Engineer
<i>Small</i> (All key stakeholder firms involved are small)	Annual Turnover	~\$ 325 million	~\$ 35 million	~\$ 80 million	~\$ 45 million	~\$ 18 million
	Designation of Interviewee	<ul style="list-style-type: none"> •Director-Residential Projects •Head of Operations 	<ul style="list-style-type: none"> •Architect •Senior Architect 	<ul style="list-style-type: none"> • Project Manager • Procurement Engineer 	<ul style="list-style-type: none"> • Head of MEP Division 	<ul style="list-style-type: none"> •Manager – Client Liaison
<i>Foreign</i> (All key stakeholder firms involved are foreign)	Annual Turnover	~\$ 825 million	~\$ 250 million	~\$ 430 million	~\$ 160 million	~\$ 400 million
	Designation of Interviewee	<ul style="list-style-type: none"> •Head of sustainability •Senior Vice President-Operations 	<ul style="list-style-type: none"> • Lead Architect • Senior Consultant - Sustainability 	<ul style="list-style-type: none"> • Regional Head - Sustainability • Head of Commissioning 	<ul style="list-style-type: none"> • Technical Manager • Manager-LEED projects •Senior Engineer-MEP & Systems 	<ul style="list-style-type: none"> •Product Specialist •Business Development Manager
<i>Local</i> (All key stakeholder firms involved are local)	Annual Turnover	~\$ 690 million	~\$ 175 million	~\$ 550 million	~\$ 180 million	~\$ 400 million
	Designation of Interviewee	<ul style="list-style-type: none"> • Chief Operations Officer • Manager – Special Projects 	<ul style="list-style-type: none"> • Head of Design • Manager – Compliance and Tender 	<ul style="list-style-type: none"> • Project Manager • Project Engineer 	<ul style="list-style-type: none"> • Project Engineer 	<ul style="list-style-type: none"> •Product Manager

of 'what', 'how', 'how much' and 'why' on the relevant GSCM relationships, such as between green drivers/barriers (external and internal) and green practices (core and facilitating); green practices (core and facilitating) and each dimension of performance (environmental, cost/economic and organizational performance); and between green practices (core and facilitating).

3.6.2.5. *Analysing the data*

With regard to data analysis, each meaningful relationship identified between GSCM sub-themes at the factor level in the interviews was coded. For example, between green drivers and practices, if the respondent highlighted government regulation as one the drivers for implementing green design and green purchasing practices, specific codes were assigned for the relationship between government regulation and green design and government regulation and green purchasing. Similarly, all the meaningful one to one relationships between factors highlighted by the respondents were coded. The overall strength of the relationships [categorized as strong (✓✓), moderate (✓) and no/low (empty cell)] for each stakeholder was then computed based on the number of mentions across all the interviews (occurrence and non-occurrence of a phenomenon) and the strength of the opinions of the interviewees (which was assigned a score of 1 to 3 by the author). For example, if government regulation was highlighted as an important driver by all eight Developer respondents in implementing green design, the relationship was given a score of 24 [8 (number of mentions) x 3 (strength of opinion)] out of the maximum possible 24 (8x3), which translates as strong (✓✓). Similarly, if only two out of the eight Developer respondents interviewed highlighted government regulation as a green driver for implementing the green design, but of low importance, the relationship was given a score of 2 (2x1) out of the maximum possible 24 (8x3), which translates as low (empty cell).

The next section discusses the survey research methodology employed in this thesis.

3.6.3 Survey research

In line with the research questions (refer Table 3.3), the aim here is to conduct a large-scale empirical, quantitative investigation to quantitatively assess the GSCM themes/sub-themes and their factors such as the 'extent of implementation of green practices (RQ1)', 'perceived importance/relevance of green drivers and barriers (RQ2)', 'extent of improvement in green

performance (RQ3)' for each stakeholder; relationships (including testing of relevant hypotheses) between the GSCM themes/sub-themes such as 'the extent of impact of green drivers and barriers on green practices (RQ4)', 'the extent of impact of green practices on green performance (RQ5)', and the 'extent of impact of facilitating green practices on core green practices (RQ6)'; and finally to understand the difference in the GSCM aspects based on firm size and firm ownership (RQ7).

Quantitative techniques can measure specific characteristics using structured data collection procedures from a large representative sample population so that results can be generalised to the entire population. A survey methodology is utilised in this thesis to collect data. It is the most widely used research strategy within business and management research (Saunders et al., 2016) as well as in supply chain/green supply chain management (Holt, 2005; Seuring and Muller, 2008; Malviya and Kant, 2015). This is because they are an effective tool to get opinions, attitudes, descriptions and investigate cause and effect relationships (Ghuari and Gronhaug, 2002). Busha and Harter (1980) state that surveys are best suited to determine the relationships between the factors such as testing of hypotheses.

According to Crossman (2013):

'surveys are commonly used tool[s] in sociological research, whether in the form of a questionnaire, interview, or telephone poll. Surveys make it possible to ask specific questions about a large number of topics and then perform sophisticated analyses to find patterns and relationships among variables'

Kerlinger and Lee (2000) list the following benefits of survey research:

- a great deal of information can be obtained from a large population;
- surveys are relatively economical;
- survey accuracy is high, especially when good sampling procedures are followed;
- surveys have a unique advantage among scientific methods as it is possible to check the validity of survey data, using various statistical methods.

Moreover, surveys are free from subjectivity as they obtain straightforward information from respondents (McIntyre, 2005). They can easily be distributed to large groups of respondents, including distant ones and the responses obtained are standardised and therefore can be easily compiled and analysed (Crossman, 2013).

The survey research framework used in this thesis is provided in Figure 3.3. The following section discusses the distinct stages of the survey research process starting with survey instrument development.

3.6.3.1 Developing the survey instrument

The survey instrument is the tool to collect data. The final survey instrument used for conducting the survey research in this thesis is given in Appendix C. This section explains the different stages in the development of the survey instrument. As shown in Figure 3.3, the different stages included initial survey instrument development, pre-testing, and pilot testing, to ensure the respondents would have no problems in answering the questions and that there would be no problems in recording the data (Saunders et al., 2016). Each stage was important as any major pitfalls could have jeopardised the entire findings.

3.6.3.1.1. Developing the initial instrument

The two important aspects that need to be considered while developing the initial instrument are the questions and the scale used to collect opinions from the respondents.

The initial survey questionnaire covering each of the GSCM themes were mainly developed from the information obtained from the interviews. The insights from the literature also helped in the framing of the questions. The questionnaire had nine sections, namely 1) external green drivers 2) internal green drivers 3) external green barriers 4) internal green barriers 5) core green practices 6) facilitating green practices 7) environmental performance 8) cost/economic performance and 9) organisational performance. Additional questions pertaining to firm characteristics (size and ownership) and demographic details of the respondents, such as years of experience and designation, were also included in the survey instrument. Since it was necessary to survey each stakeholder (Developer, Architect/Consultant, Contractor and Supplier), the main survey questions were also slightly modified and contextualised without losing comparability across stakeholders. Careful consideration was given in the wording/phrasing of each question to ensure that they accurately measured what they were intended to measure, so that the questions were not misread and that they did not encourage a particular answer (Saunders et al., 2016).

As regards the survey scale, a five-point Likert measurement scale was used to evaluate the different facets of GSCM (Likert, 1932). It is preferred because it is a powerful scale for

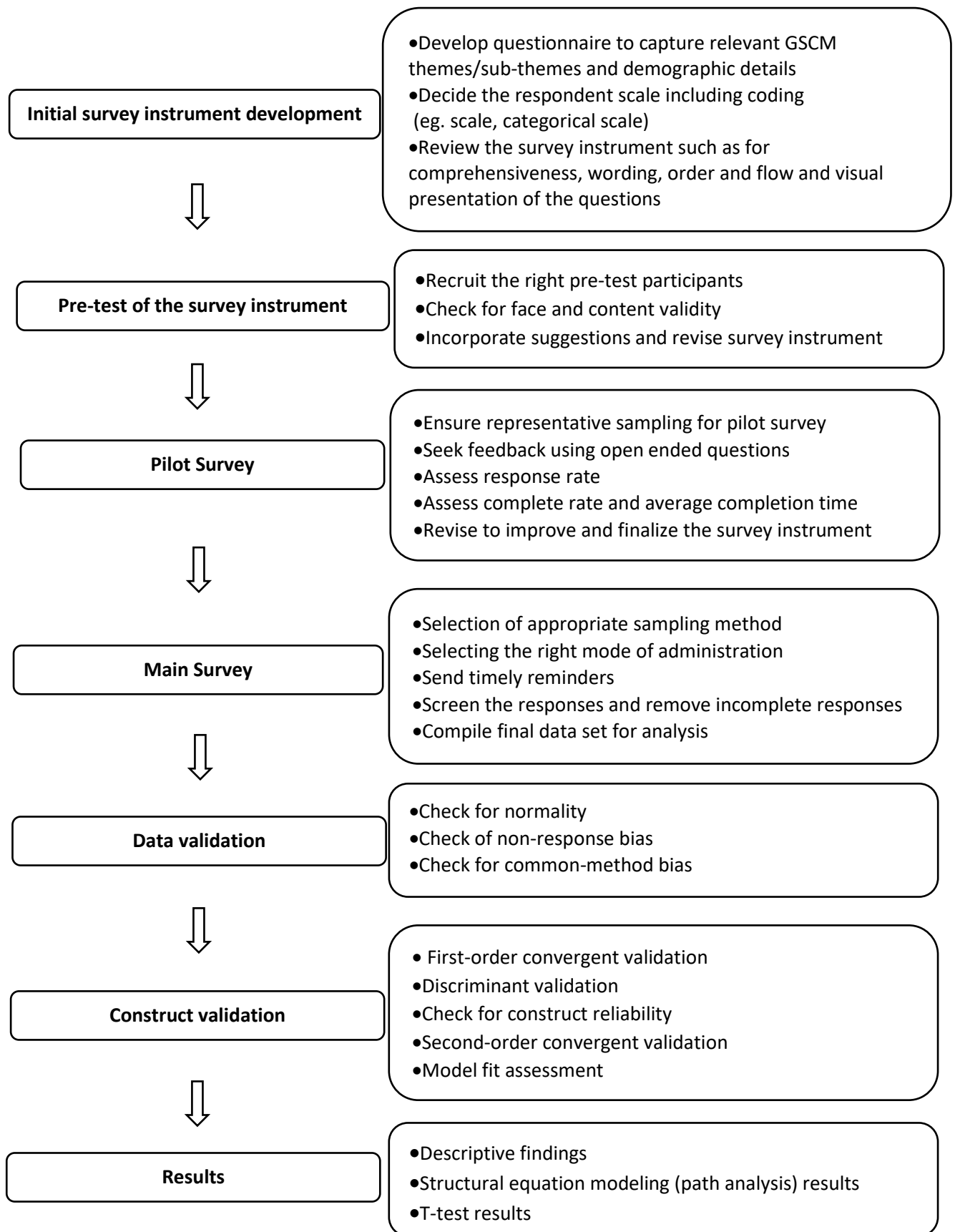


Figure 3.3: Stages of survey research of this thesis

statistical analysis (Hair et al., 2010). The scale used in this thesis is similar to the those used in GSCM research by Zhu et al. (2007) and Green et al. (2012). The majority of the questions in the initial survey instrument adopted a 5-point Likert-scale.

Since the developed GSCM survey instrument was not tested and validated previously in the construction sector, adequate measures such a pre-testing and pilot testing were undertaken to ensure the survey instrument effectively captured the GSCM aspects considered in the study.

3.6.3.1.2. Pre-test of the survey instrument

Pre-testing is asking an expert or group of experts to comment on the representativeness and suitability of the questions and allowing suggestions to be made on the structure of the questionnaire so that necessary amendments can be made before the pilot survey (Saunders et al., 2016). It is an important stage in survey research as it improves the quality of the final questionnaire (Holt, 2005). Dilman (1978) suggests that pre-test of the survey instrument is important to ensure relevance, clarity, readability, completeness and interest to the respondents. The steps taken for pre-testing were based on Reynolds et al. (1993). This involved submitting the questionnaires to different target groups (Forza, 2002).

The pre-test of the initial survey instrument was conducted using twelve senior managers (three from each stakeholder) and three academics (two from a supply chain background and one from general business management). This far exceeded the condition outlined by Ghuari and Gronhaug (2002), who state that a questionnaire should go through a pre-test of at least three to five respondents. The pre-test process with the participants involved checking the appropriateness of the questions 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. The outcomes of the pre-test are as follows:

- *Face validity*: The pre-test participants confirmed that at a generic level questionnaire makes sense.
- *Content Validity*: The pre-test participants also confirmed the content validity of the survey instrument, i.e. the measurement instrument provides adequate convergence for the domain or essence of the domain that it measures (Churchill, 1979). This reflects the rigorous process underwent in the development of the contents of the survey instrument.

- *Sequencing of questions/sections:* Question sequence is very important to ensure logic flow (Piboonrunroj, 2012). The pre-test participants' feedback was very important in re-sequencing the survey sections. For example, the initial survey instrument "green drivers" and "green barriers" sections were sequenced before the "green practices" section. Pre-test participants highlighted that the respondents would be in a better position to respond to "green drivers" and "green barriers" after completing the "green practices" section of the questionnaire. Similarly, other changes in the sequence of individual questions were made based on feedback received from pre-test participants.
- *Deletion/revision of demographic questions:* The initial survey instrument had two measures of size related questions, namely number of employees and revenues. The pre-test respondents were of the opinion that only one of them should be retained. The majority of participants preferred to use number of employees as a proxy for capturing organisational size because they highlighted that not all respondents would have knowledge of their organisation's annual revenue.
- *Suggestion on wording/grammar and general look and feel:* Pre-test respondents also gave useful feedback on the wording/choice of terminology. For example, most of the respondents suggested adding "environmental" after "green" (green/environmental) as respondents would be more familiar with the term 'environment' than green. Similarly, they suggested adding the term 'enablers' along with drivers (enablers/drivers) and 'challenges' along with barriers (barriers/challenges) was also suggested. These suggestions were incorporated in the survey instrument.

The following section discusses the outcome of the pilot survey conducted using the pre-tested instrument.

3.6.3.1.3 Pilot survey

Conducting a pilot survey is important to identify and address issues that might affect the completion of the final questionnaire during the main study (Dillman, 1978). It includes checking whether respondents had any problems understanding or answering questions and have followed the instructions correctly (Saunders et al., 2016). It is also used to make a preliminary assessment of the likely validity and reliability of the data (Saunders et al., 2016). It involves selecting a small number of respondents to examine how the questionnaire might be received by the entire sample and identify any potential problems (Holt, 2005). Although

pilot study samples are small, it is important to get a representative sample of all groups targeted in the main survey. Some of the other important aspects that can be identified from a pilot study are as follows (Bell, 1999; Holt, 2005):

- How long it took the respondents to complete the questionnaire
- The response rate (No. of completed survey returned/Total sample surveyed)
- The completion rate (No. of completed responses/No. of respondents attempted/started the survey)
- Drop out section /drop out time period (to get insights into when and where the respondents decided to exit the survey without completing it)
- Questions or sections skipped/answered not applicable (to assess questions/sections that were unclear or ambiguous and/or respondents felt uneasy about answering)
- Comments/feedback for improvement

In our pilot study, a total of 360 construction professionals from different stakeholders were contacted in spring 2015 via an e-mail containing the online survey link over a period of two months. An open-ended comments/feedback section was added at the end of the pre-test survey instrument to seek feedback for improvement. The Qualtrics online survey system⁸ was used to ensure unique responses from validated members in the panel filled the survey. The paid online construction database Zawya was used to obtain the contact details of the professionals. Targeting respondents were possible with Zawya, as it had the option to filter respondents by designation, stakeholder status, firm size and ownership. A total of 75 responses were received (response rate of 20.8%), of which 16 incomplete responses were excluded, leaving 59 responses for analysis. The breakdown of the responses includes Developer-12, Architect/consultant-19, contractor-21 and supplier-7.

- *Time taken to complete the survey:* The average time taken to complete the survey was 22 minutes. However, when excluding the outliers (greater than 30 minutes and less than 5 minutes), the average time for survey completion was 17 minutes. This slightly exceed the 15-minute time requested from respondents in the survey invitation

⁸ www.qualtrics.com

- *Survey response rate:* The usable response rate of the survey was 16.4%. This gave us an indication of how many industry professionals the main survey needed to target to get around 500 responses (intended target of the main survey)
- *Completion rate (No. of completed responses/No. of respondents attempted the survey):* This gave us an indication of how many started/ attempted the survey and how many eventually went on to complete the survey. In this pilot study, the completion rate was 78.6%.
- *Drop out section /drop out time period:* Close scrutiny of the behaviour of drop out respondents revealed that 6 respondents dropped out around the 16 to 18-minute period whilst completing all sections other than the important 'performance' section at the end. The other 9 respondents dropped out in the first 5 minutes, before finishing the demographic section at the start. While some of this dropout was expected, the overall length of the survey and the lengthy demographic section at the start could have influenced the dropout rate.
- *Questions skipped/answered not applicable:* The pilot study could not identify any questions in particular of concern that respondents intentionally skipped.
- *Comments/feedback for improvement:* The comments/feedback received was very useful for the survey. While most of the comments received were positive, there were concerns raised by a small number of respondents that the survey was lengthy. In addition, a small number of respondents highlighted that the survey had too many sections.

Some of the constructive feedback/criticism received for the pilot study was as follows:

- *"The survey is amazing and informative but lengthy"*
- *"Best part of the survey is, it includes lots of necessary and required items which people missed out in real life, such as transportation near construction site, ROI, etc. however, sections are somewhat confusing"*
- *I am not sure what the survey intends to prove. The questions are leading the survey participant to a conclusion that seems to be self-evident already*
- *Good survey. Some questions are repeated.*

Some of the positive feedback received included:

- *This survey is rated good. It promotes awareness to green buildings and to environmental protection.*

- *Very useful and quite interesting. Good source of valuable secondary data.*
- *Well structured.*

After careful consideration, following revisions were made to the survey instrument based on the insights from the pilot study.

- A short description was provided at the start of the survey, which explained the purpose of the survey.
- Demographic questions at the start were re-sequenced. Important questions for identifying the stakeholder type, size and ownership were retained at the top, while the rest were moved to the final section. This was expected to improve the survey completion rate (reduce dropout rate).
- Number of sections in the survey was reduced to four (excluding the demographics section at the start and at the end) from nine by merging external and internal drivers, external and internal barriers, core and facilitating green practices, and environmental, cost/economic and organizational performance. The four sections were: green drivers, green barriers, green practices and green performance. This was expected to reduce the average survey completion time and improve completion rate.
- Realised the need for an additional database other than Zawya to achieve the intended target of more than 500 responses given the response rate of the pilot study was only 16.4%.

The next section details the steps adopted in the main survey administration using the final, pre-tested and piloted survey instrument (refer Appendix C).

3.6.3.2 Main survey administration

An important aspect of survey administration is sampling. Sampling, or choosing the segment of the population for the investigation, is important because the sample represents the population (Bryman, 2016). Essentially, there are two types of sampling in survey research, namely probability sampling, in which samples are selected using a random selection process and each sample in the population has a known chance of being selected, and non-probability sampling in which samples are not selected using a random process (Trochim, 2006).

In this study, a purposive, convenience sampling, a non-probability sampling technique, was used to sample the targeted population, the construction sector professionals in the UAE. The

reason for choosing purposive sampling was because it allowed the researcher to make the best judgement on ways to focus on particular characteristics of a population that was of interest, which would best enable the researcher to answer the research questions. In this study, purposive sampling ensured reasonable representation from each stakeholder (Developers, Architects/Consultants, Contractors and Suppliers); from small, medium and large firms; and from foreign and local firms in line with the research objectives. Simultaneously, a convenience sample or samples that were available to the researcher by virtue of their accessibility were used. In this study, the same Zawya database used in the pilot study was utilised along with the researcher's personal LinkedIn contacts (of construction sector professionals). The advantage to both the databases is that they had filter options which allowed advanced profiling of respondents based on their stakeholder status, firm size, firm ownership and designation/role in the organisation.

The next important issue addressed in the survey administration was the final sample size because how well a sample represents the population is dependent on the sample size (Bryman, 2016). In this study, after profiling, there were approximately 2400 potential respondents, 1000 from the Zawya database and 1400 from LinkedIn contacts. Based on the response rate obtained from the pilot study (16.4%), the expected final sample size was 394. This far exceeded the sample size of any of the previous GSCM studies found in the literature. However, it is acknowledged that sample size will have a limit on the type of data analysis that can be conducted in the study (Saunders et al., 2016). For example, advanced statistical techniques, such as structural equation modelling, are sensitive to sample size. Some of the challenges faced in this study relating to sample size and data analysis and how the study addressed it are discussed later in this chapter.

The other important aspect of survey administration is the mode of administration. In this study, an online mode of administration was selected. In comparison to traditional postal surveys, online surveys are fast, convenient, manageable and cheap (Bryman, 2016). The administration was managed through Qualtrics, the same online platform used for the pilot survey. The advantage of using Qualtrics was that it allowed sending the survey via email link to the respondents. Moreover, Qualtrics surveys had smartphone compatibility, which allowing respondents to complete the survey on their smartphones. Also, the default

management reports available in Qualtrics were useful in tracking the daily, weekly and monthly response rates.

To summarise, the country-wide main survey was conducted over a period of 3 months during Fall 2015. The survey was administered via email to more than 2400 construction sector professionals from over 200 firms in the UAE using Qualtrics, a web-based survey system. Several measures to improve the response rate as suggested by studies on survey research (Dillman, 2014; Frohlich, 2002) were undertaken. Each questionnaire was accompanied by a cover letter indicating the purpose of the study and potential contributions. Previous studies have shown that a cover letter can have a positive affect on the response rate of the self-administrated questionnaire (Dilman et al., 2014; Bryman, 2016). The letter also assured the complete confidentiality of the survey to the respondents. Two follow-up reminder emails were sent out after three weeks and six weeks respectively from the start of the survey to encourage participation from nonrespondents.

A total of 517 completed responses were received, an overall response rate of 21.5%, which can be regarded as satisfactory in a survey-based study (Malhotra and Grover, 1998; Frohlich, 2002) and greater than recommended in supply chain management research (Prahinski and Benton, 2004; Pagell et al., 2004). After close scrutiny, of the 517 responses, 62 responses were removed due to incompleteness, and concerns related to respondent's lack of knowledge about green practices (identified from the survey response), leaving 455 valid and usable responses for data analysis (a usable response rate of 19.0%). The demographic characteristics of the final responses are shown in Table 3.7.

As seen in the table, a reasonable representation across all stakeholders was received. The bias of the responses towards Contractors (46.8%) was not surprising given that Contactors/Subcontractors constitute most of the construction firms in the UAE. Further, a comparable split of responses was received with regards to firm size (SMFs-47.5% and large firms-52.5%) and firm ownership (local-48.6% and foreign firms-51.4%), and was expected to enhance the validity of the study on the impact of firm size and ownership on GSCM aspects (discussed later in Chapter 10). Finally, with regards to the experience of the respondents, as seen in the table, 51% had more than 10 years of experience in the construction sector; 83% had 6 or more years of experience, and 98% of the respondents had 3 or more years of

experience. Given the wealth of experience of the respondents, the quality of responses, in general, was presumed to be high.

Table 3.7 Classification of survey respondents

	Responses	Percentage
<i>Stakeholder</i>		
Developer	60	13.2%
Architect/Consultant	105	23.1%
Contractor	213	46.8%
Suppliers	77	16.9%
Total	455	100%
<i>Size (employees)</i>		
SME	216	47.5%
Large	239	52.5%
Total	455	100%
<i>Firm ownership</i>		
Local	221	48.6%
Foreign	234	51.4%
Total	455	100%
Respondents experience (in year) in construction sector		
0-2	9	1.9%
3-5	69	15.2%
6-10	143	31.4%
>10	234	51.4%
Total	455	100.0%

3.6.3.3 Analysing the data

Before proceeding with the main analysis in answering the research questions, it was important to ensure the data collected was valid and reliable and met the underlying assumption required for conducting statistical analysis. Also, the validity and reliability of the constructs considered in the study also needed to be ensured. Therefore, the study conducted the following assessments first, to ensure the data collected were valid and reliable.

3.6.3.3.1 Assessing normality of data

One of the underlying assumptions for conducting statistical analysis such as t-test, correlation and structural equation modelling (SEM) is that the data fit a normal distribution curve (Baumgartner and Homburg 1996). Each of the surveys was assessed for normality. One

of the common tests of normality, the Shapiro-Wilk test (Saunders et al., 2016), was utilised in this study. The results indicated that the data was normal for each Likert scale items as the Shapiro-Wilk statistic was non-significant at $p > 0.5$.

3.6.3.3.2 Checking for non-response bias among survey participants

Non-response bias results when the response of the survey participants differs from the theoretical non-participants (Armstrong and Overton, 1977). Non-response bias is a concern and can affect the generalizability of the results in survey research (Bryman, 2016). Previous studies in GSCM research have warned about the potential impact of non-response bias (Zhu et al., 2011; Yu et al., 2014). While there are a number of approaches to test for non-response bias, ideally, a slimmed down version of the questionnaire to non-respondents (assuming they complete the slimmed down survey) can be used to test the differences (Carter and Jennings, 2004). Alternatively, Prendergast and Pitt (1996) suggest making phone calls to non-respondents and asking a few questions from the original survey and testing the differences. However, in this study, both these options were not feasible, given the fact that three reminders had already been sent and had proved it difficult to reach the non-respondents either by email or phone. Instead, the non-response bias test suggested by Armstrong and Overton (1977) was used. The underlying assumption in this test is that late respondents are likely to behave in the same manner as non-respondents. This test is also widely used in GSCM research (Zhu et al., 2011; Lee, 2008; Green et al., 2012).

A t-test was used to test any statistically significant differences between early and late respondents for each item in the survey. The early respondents included the 287 responses received before the first reminder email, whereas the late respondents include the 168 responses obtained after the first and second follow-up email. The results of t-tests between the two groups yielded no statistically significant differences at $p < 0.05$ level, suggesting that non-response bias was not a problem in this study (Armstrong and Overton, 1977).

3.6.3.3.3 Checking common method bias in responses

The other potential issue in this study was the issue of common method bias. This is defined as (Podsakoff et al., 2003, p. 879):

“variance that is attributable to the measurement method rather than to the constructs the measures represent”

In questionnaire-based survey research, this arises in cases where one respondent is answering all of the self-reported questionnaire involving multiple constructs (Podsakoff et al., 2003). However, in prior anticipation of this potential threat, before collecting data, procedural remedies, as suggested by Podsakoff et al. (2003), were undertaken to negate the effects of common method bias. The measures included re-assuring respondents about the data confidentiality and anonymity to prompt them to answer as honestly as possible, and conducting a pre-test and a pilot test of the survey to improve content and face validity so that the questionnaire was easily understood. To check for common method bias post data collection, Harman's single factor test, one of the most widely used in social sciences, including GSCM (Zhu et al., 2011; 2013; Yu et al., 2014), was used. In this method, all the items were loaded into one construct (factor). If that one factor explains more than 50% of the variance in the model, then common method bias is an issue. In this study, the constrained one-factor exploratory factor analysis model only explained 26.1% for Developers, 27.9% for Architects/Consultants, 18.3% for Contractors and 28.5% for Suppliers, compared to the 9-factor model which explained 79.2% of the variance for Developers, 77.1% for Architects/Consultants, 81.3% for Contractors and 71.8% for Suppliers. This indicates common method bias was not an issue in this study.

3.6.3.3.4 Assessing construct validity

Validity refers to the issue of whether a set of items (factors) that are devised to gauge a concept/theme (construct) measures that theme (Bryman, 2016). In this case, it is important to establish statistically whether the underlying factors within each GSCM sub-themes (referred to as GSCM constructs from now on) really measure that construct. There are different ways to ensure construct validity. This includes face validity, content validity, convergent validity and discriminant validity. Among these, face validity, which is the general "look like" adequacy of measures for representing the construct (Hsu et al., 2013) and content validity, which is extent to the measures are relevant and representative of the construct that they will be used to measure (Haynes et al., 1995) were already assessed and validated in our survey pre-test. However, convergent and construct validity are more rigorous and require statistical means to establish validity.

Convergent validity of constructs: This refers to the degree to which two or more measures of a construct that theoretically should be related, are in fact observed to be related (Trochim,

2006). The convergent validity of each measurement item was assessed by conducting separate (first-order) confirmatory factor analysis (CFA) for external and internal drivers and barriers, core and facilitating green practices, and environmental, economic/cost and organizational performance, using the maximum likelihood approach (O'Leary-Kelly and Vokurka, 1998), using AMOS 21.0 software.

Confirmatory factor analysis (CFA) is a statistical technique used to verify the factor structure of a set of observed variables. CFA allows the researcher to test the convergent validity (unidimensionality) of the latent constructs. The standardised factor loadings obtained (correlation between the individual items and their corresponding construct) can be used to assess the convergent validity. Convergent validity is achieved when all measured items have acceptable factor loadings for the respective latent construct. Typically, higher factor loadings (>0.5) and corresponding critical ratio above 1.96 for all measurement items shows evidence of construct validity (Anderson and Gerbing, 1988; Kline, 2014). In order to improve the convergent validity of a construct, any item with a low factor loading (typically <0.3) should be deleted. However, before the factor loadings were assessed, it was important to ensure adequate model fit for each of the separate first order confirmatory factor analysis conducted in this study.

The different model fit indices that were used in this study to evaluate the confirmatory factor models are Chi-square (χ^2) statistic, Comparative fit index (CFI), Goodness of fit index (GFI), Adjusted Goodness of fit index (AGFI), and The Root Mean Square Error of Approximation (RMSEA) (Table 3.8). The selection ensured at least one fitness index was selected from the three model fit categories, namely absolute fit, incremental fit, and parsimonious fit, as recommended by Hair et al. (2010) and Holmes-Smith et al. (2005).

CFI is usually considered as one of the most preferred indices for model fit (Bentler 1990; Byrne 2010). The CFI, which takes into consideration the sample size, assumes that all the latent variables are uncorrelated (null model) and compares the sample covariance matrix with the null model (Hooper et al., 2008). Its value again ranges from 0 to 1, with 0 indicating no fit and 1 indicating a perfect fit.

GFI calculates the proportion of variance that is accounted for by the estimated population covariance and shows how closely the model comes to replicating the observed covariance

Table 3.8 Model fit indices used in this study

Fit Index	Range	Recommended level	Reference
χ^2 / DF	0 (ideal fit) to ∞ (low fit)	<2 (excellent) <3 (good) <5 (acceptable)	Tabachnick and Fidell (2007) Carmines and Mclver (1981) Wheaton et al. (1977)
CFI	0 (no fit) - 1(perfect fit)	>0.90	Hu and Bentler (1999)
GFI	0 (no fit) - 1(perfect fit)	>0.90 (good) >0.95 (excellent)	Bollen (1990) Shevlin and Miles (1998)
AGFI	0 (no fit) - 1(perfect fit)	>0.90	Hooper et al. (2008)
RMSEA	Typically, 0 to 0.10	<0.05 (excellent) <0.08 (good) <0.10 (fair)	Hooper et al. (2008) Browne and Cudeck (1993) MacCallum et al. (1996)

matrix (Hooper et al., 2008; Diamantopoulos and Siguaaw, 2000). Its value again ranges from 0 to 1, with 0 indicating no fit and 1 indicating a perfect fit.

AGFI also ranges from 0 to 1 but adapts the GFI based upon degrees of freedom and model complexity (like the adjusted multiple r-squared) (Hooper et al., 2008; Tabachnick and Fidell, 2007).

RMSEA is regarded as one of the most informative fit indices (Diamantopoulos and Siguaaw, 2000) calculates the size of the standardized residual correlations and shows how well the model, with unknown but optimally chosen parameter estimates, would fit the population's covariance matrix (Hooper et al., 2008; Byrne, 1998).

The results of the first-order CFA exhibited acceptable model fit across all stakeholders. Moreover, except for 12 items, of all items measured across four stakeholders, have loaded significantly to their respective construct with factor loadings greater than 0.50 with a critical ratio >1.96, indicating the strong convergent validity of the constructs (details are provided in Appendix D). Further, Average Variance Extracted (AVE) (exhibited in Table 3.9) for all the relevant 48 constructs assessed across the four stakeholders was more than 50% (Fornell and Larcker, 1981), which further demonstrated convergent validity. The 12 items which failed to load were excluded from further construct level analysis.

Discriminant validity of constructs: This refers to the degree to which measures of constructs that theoretically should not be related to each other are, in fact, observed to be not related to each other (Trochim, 2006). In other words, the study should be able to clearly discriminate between different constructs, for example, external and internal drivers. Two widely accepted procedures were used in this thesis to assess discriminant validity. In the first, discriminant

Table 3.9 Average Variance Extracted (AVE) and Reliability Analysis (Cronbach's alpha)

	<u>Developer</u>		<u>Architect/Consultant</u>		<u>Contractor</u>		<u>Supplier</u>	
	α^b (No. of items)	AVE ^a (%)	α^b (No. of items)	AVE ^a (%)	α^b (No. of items)	AVE ^a (%)	α^b (No. of items)	AVE ^a (%)
External drivers	0.91 (3)	68.8	0.82 (3)	74.1	0.72 (3)	66.1	0.72 (2)	90.8
Internal drivers	0.86 (4)	52.2	0.89 (4)	75.8	0.91 (4)	79.8	0.70 (3)	57.0
External barriers	0.62 (3)	53.0	0.73 (4)	56.3	0.78 (4)	60.8	0.71 (4)	62.9
Internal barriers	0.51 (2)	73.9	0.56 (2)	51.9	0.76 (2)	65.1	0.54 (2)	54.3
Facilitating green practices	0.89 (5)	69.8	0.70 (4)	66.1	0.86 (5)	69.1	0.80 (3)	76.1
Green design	0.88 (6)	63.0	0.90 (10)	54.1	-	-	0.70 (2)	60.0
Green purchasing	0.88 (2)	86.9	0.78 (2)	79.0	0.95 (2)	91.4	0.73 (2)	67.4
Green transportation	0.91 (3)	85.5	0.82 (3)	73.9	0.92 (5)	71.9	0.86 (3)	87.2
Green construction /manufacturing	-	-	-	-	0.88 (7)	58.9	0.74 (4)	72.5
End of life green practices	0.97 (2)	95.4	0.83 (2)	83.5	0.81 (2)	69.2	0.81 (2)	53.9
Environmental performance	0.90 (7)	64.0	0.91 (7)	66.2	0.92 (7)	69.4	0.93 (7)	71.6
Economic/cost performance	0.91 (5)	75.9	-	-	0.93 (5)	83.8	0.82 (5)	62.0
Organizational performance	0.91 (5)	77.8	0.89 (5)	69.9	0.91 (5)	75.2	0.85 (5)	64.6

^aAVE is given by, $\sum \lambda_i^2 \text{Var}(X) / (\sum \lambda_i^2 \text{Var}(X) + \sum \text{Var}(e_i))$; $\text{Var}(X)$ is the disattenuated (error free) variance of X , and e_i is the measurement error of x_i .

^b α represents Cronbach's alpha coefficient of reliability

validity was checked by comparing the correlation between the constructs and the square root of the AVE of the constructs. Discriminant validity is indicated if the AVE for each multi-item construct is greater than the shared variance between constructs (Fornell and Larcker, 1981). In this study, the AVE of each construct (as shown in Table 3.9) was greater than the squared correlation between any pair of them, providing evidence of discriminant validity. In the second procedure, a series of pairwise CFA was 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 the two-factor model (Anderson and Gerbing, 1988). The pairwise tests were performed for all possible combinations, and for each stakeholder. The results showed significant deterioration in the model fit in all cases, thereby demonstrating strong discriminant validity.

3.6.3.3.5 Assessing construct reliability

Construct reliability is the degree of consistency, precision, and repeatability of the measures in the construct (Kline, 1998). Using Cronbach's Alpha (Cronbach, 1951), the reliability of each construct operationalized in this study was verified. The larger the Cronbach's Alpha, the better is the consistency in the measurement. Nunnally (1978) suggests that the Cronbach's alpha should be at least above 0.5 and preferably larger than 0.7. Table 3.9 shows the Cronbach's alpha value for each construct across the stakeholders. As seen in the table, Cronbach alpha values were well above the limit of 0.70 in most cases except for the internal barrier construct for Developer, Architect/Consultant, and Supplier, which still though was within the acceptable limit.

3.6.3.3.6 Operationalization of core green practices as a second order construct

Unlike other constructs, core green practices used in this study is a composite construct comprising of several (validated) first order constructs, namely green design, green purchasing, green transportation, green construction/manufacturing and end of life green practices. While the core green practice construct makes perfect sense from both theoretical and practical perspectives, as these are the practices undertaken by each supply chain stakeholder to minimize the environmental impact emanating from the different stages of a construction supply chain, it is still important to establish the construct's statistical validity as a higher second-order construct underlying these first-order constructs. Similar to the confirmatory factor analysis undertaken to establish the convergent validity of first-order constructs, a second-order confirmatory factor

analysis was used to establish the validity of core green practices, a higher-order construct. The two important aspects of assessing the second-order construct validity are the model fit and the convergent validity.

Assessing model fit of the second-order model: The same fit indices as shown in Table 3.8 were used to assess the model fit of the second-order model. The computed second-order model fit indices values for Developers Architects/Consultants, Contractors and Suppliers (refer Appendix E) show that the second-order measurement model fits the data well across all the stakeholders with model fit indices in acceptable ranges.

Assessing the convergent validity of the second-order model: Similar to the convergent validity of the first-order constructs, for convergent validity of second order constructs, the second-order factor loadings also should be greater than 0.5, with a corresponding critical ratio above 1.96 (Anderson and Gerbing, 1988). The results of the second-order factor analysis run separately for each stakeholder show all the second-order factor loading were well above 0.5, with a critical ratio above 1.96 (for details, refer Appendix E).

Overall, the results indicated that the second-order measurement model fitted the data well across all the stakeholders with model fit indices in acceptable ranges. This implies that core green practice can be operationalized as a second-order latent construct with the relevant first-order constructs (green design, green purchasing, green transportation, green construction/manufacturing and end of life green practices) across all stakeholders.

This finding alone has both research and practical implications. This shows that core green practice implementation should be multifaceted and should not be limited to a few specific green practices such as green design or green purchasing. Researchers, not only in construction but also in other sectors such as manufacturing, could use core green practice construct to get a high-level understanding of the combined impact of several green practices.

Now that the validity and reliability of the data is ensured, and the first-order and second-order GSCM constructs in the study have been validated, the study can proceed to the main data analysis to answer the research questions proposed in the study. The three important statistical analyses used in this study are descriptive statistics, structural equation modelling and t-test. The

application of these tests in answering the research questions is explained in the following sections.

3.6.3.3.7 Descriptive statistics to assess GSCM constructs/factors

The descriptive statistics used in the study are arithmetic mean (\bar{X}) (or simply referred to as the mean) and standard deviation. The mean or average (M) is the most popular and well known measure of central tendency, and standard deviation (SD) is the most popular measure for spread or dispersion within a set of data. Standard deviation is usually reported along with mean because it significantly enhances the interpretation of the mean. Though simple, the mean is a powerful measure to assess the relative importance of factors and constructs (by calculating the mean of individual factor means or simply mean of means).

The factor mean (mean of individual items) and the construct mean (mean of individual factors) are used in this thesis to answer the second part of the research questions RQ1, RQ2 and RQ3, more specifically, the extent of implementation of green practices (RQ1)', 'perceived importance/relevance of green drivers and barriers (RQ2)', and 'the extent of improvement in performance (RQ3)' for each stakeholder.

3.6.3.3.8 Structural equation modelling to assess relationship between GSCM constructs

Structural equation modeling (SEM) was used as the main statistical analysis technique to assess the relationship between the GSCM constructs in line with the research questions, namely 'the extent of impact of green drivers and barriers on green practices (RQ4)', 'the extent of impact of green practices on green performance (RQ5)', and the 'extent of impact of facilitating green practices on core green practices (RQ6)'. It is a powerful statistical tool that combines a measurement model (confirmatory factor analysis) with a structural model (path analysis) into a simultaneous statistical test (Garver and Mentzer 1999). SEM was preferred over other approaches in this study because it can assess relationships between unobserved latent constructs (Lei and Wu, 2007). Moreover, it has the ability to handle multiple relationships simultaneously and efficiently (Garver and Mentzer 1999). The proposed models in this study, as shown in Figure 3.4-3.6, to test the relevant hypotheses associated with each research question at the strategic level require testing multiple relationships between latent constructs

simultaneously. However, SEM is susceptible to sample size. Although there are no strict guidelines on the sample size for SEM, the minimum sample size recommended by researchers for the use of maximum likelihood estimation, the estimation technique in SEM used in this study, is approximately 200 (Kline, 2005; Lei and Wu, 2007), though a sample size of 100-150 with no missing values was found to provide valid results (Muthén and Muthén, 2002; Tinsley and Tinsley, 1987; Anderson and Gerbing, 1988).

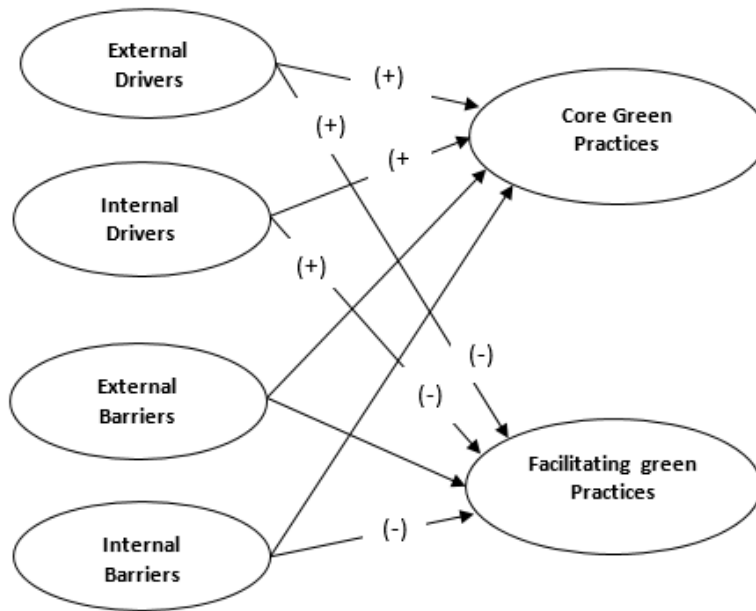


Figure 3.4 Strategic level GSCM driver-barrier-practice model

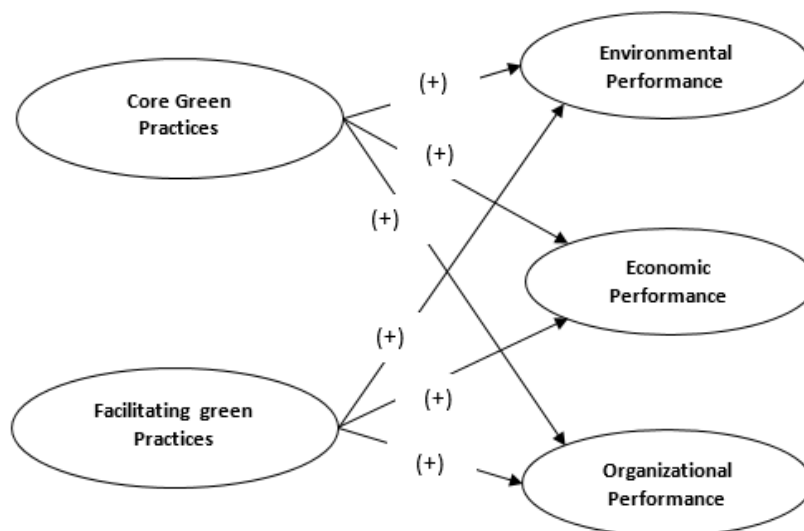


Figure 3.5 Strategic level GSCM practice-performance model

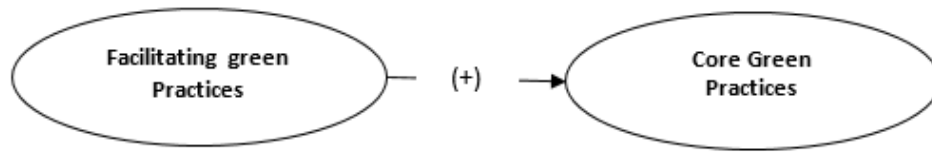


Figure 3.6 Relationship between facilitating and core green practices

While the final sample size of this study (455 responses) appeared sufficient to run SEM, the study still faced challenges in running full-fledged structural equation modelling. This is because the study was required to conduct SEM and test the hypotheses 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 number of responses. To counter this issue of sample size, instead of conducting a full-blown SEM, the study adopted path analysis (PA), a special case of structural equation modelling (SEM). This was justified given that the study at this point is interested in the relationships between the constructs rather than the confirmatory factor loading, which in any case was assessed already.

The advantage with path analysis is that it overcomes the issue of sample size by using factor scores of each construct (obtained during the confirmatory factor analysis). By doing so, each construct can be represented by a variable. This approach is consistent with the prior work of Zhu et al. (2013) in green supply chain management, in which path analysis is used over full-fledged SEM. AMOS 21.0 software was used to conduct the path analysis.

3.6.3.3.8 T-tests for testing differences in GSCM for firm size and ownership

The t-test is the most commonly used statistical method to evaluate the differences in means between two groups (Gold, 2013). In this study, independent sample t-test was used to test the difference in the GSCM constructs between small and medium firms (SMFs) and large firms, and between local and foreign firms across all stakeholders.

3.7 Summary

Research questions play a pivotal role in mixed methods research. In this thesis, too, designed in the spirit of pragmatism, the primary objective was to comprehensively answer the research

questions. This chapter discussed the research process detailing the assumptions, approach, steps, methods and techniques undertaken in this thesis including its rationale in answering the research questions.

Next, the thesis will discuss the findings of the study. Though there are no conventions associated with reporting the results of mixed methods research, Bryman (2016) recommends that at the end of the study, findings obtained through different methods need to be integrated to provide a full understanding of the research questions under study.

The study, therefore, will integrate the findings from interviews and survey as well as bring in theories and literature findings wherever possible to comprehensively answer the research questions. The following chapters in this thesis are organised in such a way that each chapter answers each of the proposed research questions in sequence. This makes it easier to relate the findings to the research questions.

Chapter 4 – Assessing the Green Practices’ Implementation in the Construction Sector

In line with the first research question (RQ1), the objective of this chapter is to develop a comprehensive understanding of the various core and facilitating green practices implemented in the construction sector by each supply chain stakeholder (Developers, Architects/Consultants, Contractors and Suppliers), including their extents of implementation. Therefore, the study will attempt to develop a comprehensive picture by integrating the findings from interviews and survey. Also, wherever possible, established/emerging theories will be used to underpin the findings and link them to the larger body of GSCM literature.

However, any effects of firm size and ownership on green practices implementation is separated from this chapter to the extent possible and will be discussed separately in Chapter 10. Also, the causal relationships between green practices and others GSCM aspects such as drivers, barriers and performance are also not discussed in this chapter as they are discussed in detail in Chapter 7, 8 and 9, though there may be some passive references to them in this chapter. The following sections will discuss in sequence each of the green practices identified and their extent of implementation in the construction sector.

4.1. Assessing core green practices’ implementation

First and foremost, the qualitative investigation (interviews) in general found all the core green practices identified from the generic and construction literature to be very relevant and important for the construction sector. These include green design, green purchasing, green transportation, green construction/green manufacturing and end of life green practices. The findings related to each of these core green practices and its relevance/non-relevance for each stakeholder is discussed in the subsequent sub-sections. In each sub-section, first, the underlying aspects (factors) within each core green practice identified from the interviews are discussed, followed by the discussion on the extent of implementation of each of these factors based on the results of the country-wide survey.

4.1.1 Assessing green design practices

This involves all related practices to integrate environmental consideration during the building design and material/product design (in the case of Suppliers). This stage is of paramount importance for the sector, as considerations made during this stage could significantly and directly reduce the environmental impacts during the operational phase of building [responsible for 80% of the total life cycle environmental impact according to Ng et al. (2012)], 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).

It was clearly evident from the interviews that the key supply chain stakeholders involved in the green building design stage are the Developers and Architects/Consultants. In most occasions, the Developers interviewed had their own in-house design team including LEED certified professionals; yet, in almost every project, the building design is developed in tandem with one or more Architectural/Consulting firms. Still, Developers, especially their in-house design team, were found to play a predominant role in the green design prospects of the project since they are the ones who are responsible for the project initiation. Most of the green design goals of the project are defined by the Developers at the pre-design, project concept definition stage. With regards to Contractors, apart from few rare cases where they are awarded the design and build responsibility, they were found to play no role at the design stage. They were found to enter the project after the design is finalised and hence had limited role in making any design related contributions including green ones.

With regard to the actual practices, most interviewees from the Developers and Architects/Consultants acknowledged the importance of environmental impact assessment of the building design to understand any potential effects on the surrounding flora and fauna of the building. The importance attached to it can be gauged from the words of a Developer interviewee:

“Since our environmental impact is not only on land but also at sea, we have taken measures to ensure that aquatic or marine life is not affected by our project, even if it means relocation or building artificial reefs.”

Although the United Nations Environment Programme (2005) has stressed the importance of environmental impact assessment of a project during the design stage, there are only a few passive mentions in the literature regarding environmental impact assessment of projects (Lam et al., 2010; Zhang et al., 2011).

The other important green building design aspects stressed by the interviewees include consideration of the building shape and orientation to increase passive ventilation and natural lighting to cut down on the energy requirements of ventilation and lighting. This is in line with previous studies that stressed the importance of natural ventilation and passive ventilation technology to reduce energy consumption in buildings (Zhang et al., 2011; Ng et al., 2012).

Respondents also acknowledged the importance of considering the waste water recycling system during the design stage. Few respondents pointed out the fact that UAE has one of the highest per capita water consumption in the world. Previously, none of the studies reviewed has mentioned considering waste water recycling during the design stage, though this is a practice that can be incorporated into any building.

The other important design consideration stressed by the respondents is the percentage of renewable energy generated vis-à-vis the total energy requirement of the building. According to respondents, the common renewable energy considerations include rooftop solar powered water heaters and solar panels connected to the electric grid to offset some of the buildings energy requirements. For example, one of the Developers interviewed highlighted that they were able to generate 12% of the energy requirements in one of their projects - a 30-storey building. This is in accordance with previous studies that highlighted the importance of integrating renewable energy in buildings such as solar panels and green roof technology (Zhang et al., 2011) and use of Building Integrated Photovoltaic (BIPV) (Abidin, 2010) to generate clean electricity from solar energy.

Interviewees also highlighted the importance of having energy efficient heating, ventilation and air-conditioning (HVAC) systems in buildings. This echoes the concerns raised by previous researchers who highlighted that heating and cooling in buildings alone accounts for 84%–94% of life cycle energy use (Chen et al., 2010).

The other important green design consideration stressed by the interviewees is the importance of modular design, especially in the community development projects where there are multiple building units with the same design build. Some of the common modular design aspects that are considered by respondents include a provision to use pre-fabricated components such as bathroom pod, balcony, etc. Surprisingly, the study also came across a small number of Developers and Architects/Consultants who are making modular design consideration for easy disassembly during the end of life. According to these respondents, modular design maximises recovery and recyclability of materials during building demolition. This shows that the UAE is maturing with regards to GSCM. The evidence from the literature indicates that prefabrication and modular design has been in existence since the 1990s in countries such as Hong Kong, Denmark, Netherlands, Sweden and Germany (Jaillon et al., 2009; Chen et al., 2010), but has not been widely practised in other countries. The other design consideration stressed by the respondents is the consideration of building materials during design. Interviewees highlighted the importance of using materials with high recycled content and low embodied energy as well as a reduction in the use of materials with harmful/hazardous content. For example, respondents highlighted the concerted efforts to reduce materials such as Asbestos, lead-based paints and varnishes, etc. In addition to the above green design considerations, a few respondents also suggested potential green design practices such as glazed façade (for reflecting sunlight) and integration of water saving technologies for shower heads, taps and toilets.

In the case of Suppliers, the green design aspects primarily involved consideration of raw materials with high recycled content and low embodied energy and reduction/elimination of hazardous materials. This is very similar to the green design practices seen in other manufacturing sectors (Zhu and Sarkis, 2004; 2006)

Now that the potential green design practices (factors) have been identified, next, the study will assess the extent to which each of these (relevant) green design practices is implemented by stakeholders in the construction sector based on the survey results. As mentioned earlier, because of the minimal/limited involvement of Contractors in the design stage, the study has abstained from asking green design related questions to Contractors. Similarly, the study has contextualised the questionnaire to ensure that Developers and Architects/Consultants respond

with regard to building design while Suppliers respond to relevant questions on green product/material design.

The mean scores of individual items/factors of green design and overall green design construct mean (the average of all individual green design practices) for relevant stakeholders obtained from the survey are shown in Table 4.1.

Table 4.1 Extent of implementation of green design by each stakeholder

Individual green design practices	Developer Mean	Architect/Consultant Mean	Contractor Mean	Supplier Mean
Consideration for environmental impact assessment of projects	3.1	3.9	-	-
Consideration for natural ventilation	3.8	3.8	-	-
Consideration for natural lighting	4.0	4.1	-	-
Consideration for waste water recycling	3.8	3.9	-	-
Consideration for photovoltaic panels	2.9	3.4	-	-
Consideration for energy efficient lighting system	3.8	4.1	-	-
Consideration for energy efficient heating and air conditioning (HVAC) systems	3.6	4.1	-	-
Consideration for modular design/prefabricated components	3.2	3.7	-	-
Consideration for materials with high recycled content and low embodied energy	2.9	3.4	-	4.5
Consideration for reduction in the use of hazardous materials	3.6	3.8	-	4.5
Overall extent of implementation of green design practices	3.5	3.8		4.5

**Mean is measured on a scale of 1 (Strongly disagree) to 5 (Strongly agree) ‘-’ indicate the item is not relevant for the stakeholder.*

Here the respondents’ opinions are captured on a Likert scale of 1-5, where 1 indicates that the underlying green design practice is not considered at all, whereas 5 indicates the underlying green design practice is highly considered. For example, as seen in Table 4.1, a mean score of 4.1 obtained for ‘consideration for energy efficient lighting system’ for Architects/Consultants, shows that a relatively high consideration is given by Architects/Consultants for this particular green design practice. Similarly, a mean score of 2.9 for ‘consideration for photovoltaic panels’ shows that this particular practice is given relatively low consideration by Developers.

As seen in the table, the implementation of green design, in general, is higher among Architects/Consultants in all the individual aspects (except for natural ventilation) compared to Developers. This shows that the Architects/Consultants in the UAE are capable of assisting Developers in green design provided they are willing to work with them. This echoes the comment made by one of the Developers, who insisted that the Developer should give more independence to Architects/Consultants in the design aspects and that their team should only guide and review the work of Architects/Consultants. Still, there is plenty of room for improvement for both Architects/Consultants and Developers given that their overall construct means for green design are 3.5 and 3.8 respectively on a scale of 1-5, with 5 being the highest score. Still, these scores are comparable to the mean scores received on a similar 5-point scale (1-5) for green design in other sectors such as Power (3.7), Chemical/Petroleum (3.5), Electrical/Electronic (3.5), Automobile (3.4) and manufacturing (3.4) (Zhu et al., 2008c; Green et al., 2012). In the case of Suppliers, the two design-related aspects surveyed had high scores (well above 4.0). This is encouraging for the sector as it shows that construction Suppliers are embracing green design aspects in their product/material design.

4.1.2 Assessing green purchasing practices

As previously stated, green purchasing practices involve the integration of environmental considerations into purchasing policies, programs, and actions. It was evident from the interviews that the key supply chain stakeholders involved in the green purchasing activities are Developers, Contractors and Suppliers. The Architects/Consultants are not directly involved in any purchasing activities in a construction project. However, they do play an indirect role in purchasing by advising the Developers on the technical aspects. In the words of one of the Consultants: *'Technical evaluation of the tender is done by us [Consultant], while the financial evaluation is done by the Developer, and the final decision, of course, will rest with the client [Developer], but we ensure [this process] is fully compliant including green aspects, and we don't even know who is the cheapest.'*

It was evident from the interviews that the Developers' main purchasing activities involved procuring the services of Architects/Consultants for all the design related activities and Contractor(s) for the construction activities. In multiple occasions, the study found instances of

the Developers pre-qualifying Architects/Consultants to participate in the design tender based on their previous experience (minimum two/three years) in green/LEED projects and/or based on a number of LEED certified professionals on their payroll. The actual awarding of Contract (from the pre-qualified Architects/Consultants) was based on the 'overall score' which includes appropriate weights for the environmental aspects (10-30%), in addition to traditional aspects of cost, quality and time. Similarly, environmental considerations in the procurement of services from the Contractor involved the mandatory requirements of EMS and ISO 14001 certification, previous track record and at least one/two LEED certified professionals to pre-qualify for tender participation. In the awarding of tender, appropriate weight, typically 5% to 20%, is given to the environmental plan (including comprehensive waste management plan) proposed by the Contractor to minimise the environmental impact of construction activities. Varnas et al. (2009) previously highlighted the importance of green procurement in the Swedish construction sector.

With regards to Contractors, the main purchasing activities involve procuring specialised services from Subcontractors and material purchases from Suppliers. Though most Contractors were found to incorporate environmental consideration in purchasing functions, their stringency was found to vary. For example, a small number of Contractors in this study are very stringent in the environmental aspects, and even mandate Subcontractors and Suppliers to sign a UN global compact, a commitment to protect the environment, before doing any business. On the other hand, there were also a small number of Contractors whose commitment is limited to implementing paperless transactions/electronic invoicing to reduce paper transactions associated with the purchasing function. The common green aspects considered in the procurement of services from Subcontractors include pre-qualification criteria such as the mandatory implementation of EMS and ISO 14001, previous LEED project experience and a minimum number of LEED certified professionals. In the case of material purchase decisions, some of the environmental aspects of the purchasing functions identified in this study include request for product sheet with environmental aspects, request for any third-party green/environmental certifications, request for self-compliance reporting on environmental aspects, testing of material samples for green compliance before awarding contract, visiting the manufacturing facility to ensure Supplier's green capabilities, random, ad-hoc environmental

audit of Suppliers and selection of Suppliers based on proximity to the construction site to minimize the environmental impact of material transportation. While some of these are previously reported by Ofori (2000), several aspects of green purchasing identified from the interviews have not been reported previously in the literature. This is an important contribution given that green purchasing is an important aspect in greening the construction supply chain (Ofori, 2000).

In the case of Suppliers, the environmental considerations made during purchasing include the purchase of raw materials with low embodied energy, raw materials that require less treatment and processing, electronic invoicing, and purchasing of raw materials from close proximity.

Overall, the identified green purchasing/procurement practices can be broadly classified into environmental consideration made during material purchases and during awarding of tender. The extent of implementation of these practices across the sector, captured through the survey are given in Table 4.2. Here, the study abstained from asking green purchasing related questions to Architects/Consultants, because as stated, they are not involved in any direct purchasing in the project, unless they are authorised by the Developer/Client, which is very rare.

Table 4.2 Extent of implementation of green purchasing by each stakeholder

Individual green purchasing practices	Developer Mean	Architect/ Consultant Mean	Contractor Mean	Supplier Mean
Environmental criteria are included in material purchase decisions	3.3	-	3.8	4.2
Environmental criteria are included in tendering	3.2	-	3.7	4.1
Overall extent of implementation of green purchasing practices	3.3	-	3.8	4.2

**Mean is measured on a scale of 1 (Strongly disagree) to 5 (Strongly agree); '-' indicate the item is not relevant for the stakeholder.*

The pattern of the results is similar to that of green design. The green purchasing activities are relatively lower for the Developer and highest for the Supplier. Again, the low score for Developers is a concern for the sector. However, the results were not surprising given that Developers still largely rely on the financial aspects of the tender bid in awarding the contract. On the positive side, the relatively high score for Contractors vis-à-vis Developers is promising for the sector given that Contractors in a typical construction project award hundred if not thousands

of purchase contracts. Yet, there is still significant scope for improvement. Suppliers in the UAE again demonstrated they are ahead in environmental aspects compared to other stakeholders. Compared with the findings in other sectors, the green purchasing practices are comparable or even higher than the green purchasing practices assessed on a similar 5-point scale (1-5) in sectors such as Power (3.3), Chemical/Petroleum (3.2), Electrical/Electronic (3.5), Automobile (2.7) and manufacturing (2.9) (Zhu et al., 2008c; Green et al., 2012)

4.1.2 Assessing green transportation practices

As mentioned previously, green transportation practices involve practices undertaken to minimise the environmental impact from all transportation-related activities in the construction project. Though the relevance of green transportation is higher for Contractors and Suppliers, this study also attempted to probe as much as possible other stakeholders to understand their green transportation practices.

As evident from the interviews, for Contractors, transportation-related activities involve both material transport and employee transport. According to respondents, the common green transportation practices considered to reduce emissions from material-related transportation include a preference for full truckload and use of fuel-efficient vehicles. However, a small number of Contractors have also considered traffic conditions to minimise transportation time and help reduce traffic congestion. As regards minimising emissions relating to employee transport/travel, the common practices identified from the study include providing employee accommodation near project sites and use of video conferencing to minimise employee travel. One of the Contractors interviewed also encourages employees to share transport (mainly with colleagues) or use public transport to reduce their employee travel related footprint. Similar practices were also witnessed among Suppliers. Full truckload transportation is common among material Suppliers. A few Suppliers were also found to plan their deliveries to avoid traffic congestion.

With regard to Developers and Architects/Consultants, since they are not involved directly in any material related transport, green transportation practices are limited to reducing employee transport/travel. The practices identified in Developers and Architects/Consultants include the use of video conferencing and encouraging employees to use public transport.

Given that none of the green-related studies reviewed in the construction sector (refer Table 2.5) discussed green transportation, the understanding gained from the potential green transportation practices that could be implemented in the construction sector is novel in nature. Practitioners and policymakers in the UAE and elsewhere could implement these green transportations to reduce the related carbon emission, which, according to Ng et al. (2012), account for up to 6-8% of the carbon emissions in construction projects. Also, some of these practices identified are relevant for other sectors too, and therefore practitioners could adapt these practices to their respective sector.

The survey findings on the extent of implementation of green transportation practices by stakeholders are given in Table 4.3.

Table 4.3 Extent of implementation of green transportation by each stakeholder

Individual green transportation practices	Developer Mean	Architect/ Consultant Mean	Contractor Mean	Supplier Mean
Accommodation for employees near project sites is provided	2.8	3.3	3.7	-
Video conferencing is used instead of face to face meetings	3.0	3.4	3.5	3.4
Employees are encouraged to use shared transport and public transport	2.8	3.4	3.7	4.0
Materials are transported in full truckload quantities	-	-	3.8	4.2
Materials are transported in fuel efficient vehicles	-	-	3.5	3.7
Overall extent of implementation of green transportation practices	2.9	3.4	3.6	3.8

**Mean is measured on a scale of 1 (Strongly disagree) to 5 (Strongly agree); '-' indicate the item is not relevant for the stakeholder.*

As seen in the table, the green transportation practices of both Contractors and Suppliers are moderately high. Though slightly lower, it is still encouraging to see Architects/Consultants, too, implementing practices to minimise employee transport. However, here again, the concern is the Developers, as their practices vis-à-vis other stakeholders is relatively low.

4.1.4 Assessing green construction/manufacturing practices

As stated before, green construction involves practices aimed at minimising the environmental impact during the physical construction phase. Since only Contractors are involved in the physical construction of the building, this practice is relevant only to Contractors. However, for Suppliers, the corresponding practice is green manufacturing, which involves practices aimed at minimising the environmental impact during the manufacturing process of a material/product.

The interview findings show that the green construction practices varied significantly across firms. The common practice found across most firms involve onsite waste segregation for the recycling and reuse. This is in line with the previous studies in the construction literature that highlighted the importance of waste management in onsite construction activities (Begum et al., 2007; Jaillon et al., 2009). Interview respondents also highlighted the use of prefabrication in construction but acknowledged that it would depend on the flexibility/provision in the design. Respondents pointed out several benefits of prefabrication in onsite construction such as reduction in onsite construction activities and project completion time, reduction in waste and energy, especially in community development projects with several identical buildings. This is in accordance with the previous findings in the literature, which recommend the use of precast facades, staircases, partition walls, semi-precast slabs, and precast bathroom pods in onsite construction to reduce onsite environmental issues (Jaillon et al., 2009). Lawton et al. (2002) estimated as much as a 70% reduction in onsite concrete use by using volumetric prefabrication, which shows the significant waste reduction potential of prefabrication in onsite construction activities.

The other common green construction practice identified from the interviews is the use of automation such as onsite concrete mixers, fillers and spreaders and onsite machinery to replace most of the manual works and, consequently, to minimise manual waste and re-works from errors. While these practices are prevalent in the construction sector to make project completion faster and easier, there is little reference in the literature that links automation and environmental benefits. Therefore, the findings from the interviews are therefore important to enable practitioners to consider automation and use of machinery/equipment from an environmental perspective.

The other aspect identified from the interviews is the concerted effort to reduce the use of hazardous materials in construction, and reduction/safe disposal of hazardous waste. This is an important finding, given that there is hardly any mention in the construction literature regarding the reduction in the use of hazardous materials in onsite construction.

A few contractors were also found to use energy efficient machinery for construction. Previous studies have stated the importance of using equipment/machinery with higher energy efficiency to reduce energy consumption in onsite construction activities (Lam et al., 2010; Qi et al., 2010). In addition, onsite green practices, such as using temporary solar panels for site offices and onsite wastewater recycling, were seen in selected projects but not a common practice among Contractors. Similarly, one Contractor interviewed was found to use recycled concrete in projects despite the hassle of taking special approval from the Developer/Consultant by providing scientific lab test reports to prove that the quality of the recycled concrete is better than that of normal concrete.

In the case of Suppliers, most of the interviewed Suppliers had state-of-the-art manufacturing facilities to minimise the emissions and waste discharge during the manufacturing process. The heightened use of technology in manufacturing, therefore, was found to reduce manual waste and errors. In fact, one of the glass manufacturers interviewed was able to reduce emission levels by 60% and energy consumption by 30% through such manufacturing facilities. These practices were similar to the green manufacturing practices identified in the generic literature for other sectors (Mutingi et al., 2014).

The survey findings on the extent of implementation of these green construction practices across the sector are provided in Table 4.4.

As seen in the table, the findings indicate that the green construction practices are moderately high and consistent for Contractors. For Suppliers, the green manufacturing practices were found to be even higher and consistent. The findings overall are encouraging for the sector since onsite construction and material/product manufacturing has significant environmental implications.

Table 4.4 Extent of implementation of green construction/manufacturing by each stakeholder

Individual green construction/manufacturing practices	Developer Mean	Architect/ Consultant Mean	Contractor Mean	Supplier Mean
Waste water is recycled project/manufacturing site	-	-	3.9	4.2
Prefabricated components are used in projects	-	-	4.0	-
Materials with high recycled content and low embodied energy are used in projects	-	-	3.8	-
Use of hazardous materials is reduced in projects	-	-	4.2	-
Comprehensive waste management plan is executed at project/manufacturing sites	-	-	3.9	4.3
Automation is use for onsite construction/ manufacturing activities	-	-	3.9	4.4
Energy efficient machinery/equipment are used at project/manufacturing sites	-	-	3.7	4.3
Overall extent of implementation of green construction practices	-	-	3.9	4.3

**Mean is measured on a scale of 1(Strongly disagree) to 5 (Strongly agree); '-' indicate the item is not relevant for the stakeholder.*

4.1.5 Assessing end of life green practices

End of life green practices are aimed at minimising the environmental impact of buildings during demolition at the end of their useful lives. Compared to other practices, end of life green practices are less discussed during the interviews. In most cases, this aspect had to be probed to get a response from the interviewees. However, it was evident from the interviews that the decision is made by the Developer in tandem with Consultants on how to demolish the building, whether it is a fast, unplanned process of all waste going to landfill or whether to carry out a carefully planned demolition process. Unlike green building design, demolition Contractors were also found to be involved in the demolition planning process. In most cases, an environmental impact assessment was carried out before the demolition activities, which include details on the equipment and machinery required to carry the demolition activities, impact on the surrounding flora and fauna, potential noise, and soil and water pollution of nearby sources. Finally, after careful demolition, waste is segregated to the extent possible to maximise the recovery of recyclable materials. While there are few details on how to carry out end of life green practices in the literature, studies have shown that end of life green practices have the potential to save

up to 50% of the embodied energy in materials/products, up to 30% of the life cycle energy, and GHG emissions by almost 18% (Yan et al., 2010; Blengini, 2009).

In the case of Suppliers, none of the material/product Suppliers interviewed has a mechanism in place to recover their product/material after the building's useful life.

The survey findings on the extent of implementation of end of life green practices across the sector are provided in Table 4.5. Here, Suppliers were not asked about end of life-related green practices questions, because, in the interviews, they were found to have no involvement in the end of life green practices

Table 4.5 Extent of implementation of end of life green practices by each stakeholder

Individual end of life green practices	Developer Mean	Architect/ Consultant Mean	Contractor Mean	Supplier Mean
Environmental impact assessment is conducted for end-of-life demolition of projects	2.6	3.4	3.7	-
Materials from the (end-of-life) demolished projects is recycled	2.7	3.3	3.6	-
Overall extent of implementation of end of life green practices	2.6	3.3	3.7	-

**Mean is measured on a scale of 1 (Strongly disagree) to 5 (Strongly agree); '-' indicate the item is not relevant for the stakeholder.*

The findings demonstrate the Contractors' capability and keenness to execute environmentally friendly demolition projects. Again, it is the Developer that emerged to be the laggard in end of life green practices. This is a concern given that the Developers set the cost and timeline of the demolition process.

4.2. Assessing facilitating green practices' implementation

This section discusses the facilitating green practices or practices undertaken at an intra-firm level to build resources and capabilities in order to achieve environmental goals. The various practices and their extent of implementation identified from the interviews and survey findings are discussed in the following section.

Like core green practices, our qualitative investigation (interviews) found all the facilitating green practices identified from the generic and construction sector literature to be very much relevant

and important for the construction sector. This includes environmental management systems and ISO 14001, environmental training, environmental auditing and cross-functional integration. However, the investigation found one additional facilitating green practice, namely, green-related research and development, which has not been discussed previously in the GSCM literature in any sector let alone construction. Moreover, all these facilitating green practices were found to be relevant for all stakeholders.

In each of the following sub-sections, the details related to each of the facilitating green practices identified from the interviews are discussed. The final section discusses the extent of implementation of these facilitating green practices in the sector based on the survey results.

4.2.1 Assessing environmental management systems and ISO 14001

Almost all the interviewed firms across all stakeholders acknowledged the importance of EMS, which consists of a collection of internal policies, assessments, plans and implementation actions. Moreover, respondents also stressed the importance of getting the EMS certified by a recognised international body. In fact, more than two-thirds of the interviewed firms were found to have their EMS certified with ISO 14001, the most widely recognised international standard. This is in line with the increasing trend for ISO 14001 certification (320 in 2010 to 1520 in 2015) seen among UAE companies including construction (ISO, 2016).

Overall, the findings are in accordance with the GSCM literature in construction and other sectors, which have stressed the importance of EMS and ISO 14001 for firms to 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; Ofori et al., 2000; 2002; Zhu and Sarkis, 2004; 2006).

4.2.2 Assessing environmental training programs

The importance of conducting environmental training programs was widely acknowledged by respondents across all the stakeholders. However, differences in the nature of training programs were observed across firms. This includes a decision on whether to give training to own employees only, or to other stakeholder's employees also; and whether to include all employees or select employees, on short training programs or long training programs etc. For instance, in

the case of Developers, most of the interviewed firms were found to include both their employees as well as Contractors' and Supplier's employees also in their training programs. Most the Developers had a dedicated in-house training department that conducts environmental training programs, though they also invite Architects/Consultants to conduct training programs for their employees. The Developer training programs were found to vary across firms. For some, the training programs were based on a well-planned curriculum with different learning levels that last for six months to one year. Some Developers also had their own in-house developed certification programs. Others, encouraged their employees by partially or fully funding them to get certified from third party providers such as LEED certification.

In the case of Architects/Consultants, the environmental training programs were more intense, frequent and extensive. Most of their employees are covered in the training programs. Also, Architects/Consultants were found to provide environmental awareness training, especially to Contractors and Suppliers. The majority of the interviewed firms are also encouraging/forcing their employees to get certified in LEED or other international certifications within a given time frame.

In the case of Contractors, the environmental training programs were found to be delivered mostly to their own employees but at all levels. For instance, the coverage of the training programs includes high-level executives to managers to unskilled onsite workers. Several contracting firms interviewed had regular training programs for their unskilled employees on how to minimise onsite waste and on how to avoid errors or mistakes that lead to waste.

In the case of Suppliers too, the training was limited to their own employees. Training programs were mainly focused on the operational aspects of the manufacturing plant such as on waste minimization and pollution reduction.

The findings, in general, echo the previous findings in the construction sector. For instance, Begum et al. (2009) highlighted the importance of environmental training and education to change negative attitudes towards environmental protection in the Malaysian construction sector. Shen and Tam (2002) also acknowledged the lack of trained staff on environmental issues as a major barrier in Hong Kong construction. Tam et al. (2011) stressed the importance of

environmental education and training of all staff in companies to increase organisations' commitment to sustainable construction.

4.2.3 Assessing environmental auditing activities

The importance of conducting environmental auditing programs was also widely acknowledged by respondents across all the stakeholders. For instance, both in-house and external environmental auditing was undertaken by most of the Developers interviewed. These audits (scheduled or unscheduled) were either undertaken by themselves or by third-party auditors. Similarly, most Consultants interviewed were found to conduct an in-house audit of ongoing projects to ensure conformities in the execution of tender as well as an external audit of Suppliers. Contractors and Suppliers auditing were focused mainly on internal auditing on their conformance to tender specifications, though some Contractors were found to conduct random audits of their Subcontractors and Suppliers, including a visit to their manufacturing facilities. However, the stringency of in-house auditing activities was found to vary across all stakeholders. The findings are in accordance with the few studies in the construction literature that stressed the importance of in-house auditing (Tam et al., 2006) and external auditing (Ofori, 2000).

4.2.4 Assessing cross-functional integration for greening

The interviewees in general across all stakeholders recognised the importance of cross-functional integration among departments and functions for achieving the environmental goals of the firm. For instance, in the case of Developers, most of the interviewed firms were found to use cross-functional teams for greening across sales, purchase and environmental departments and were found to work together right from the project concept stage till hand over. In general, across stakeholders, it was evident that typically one member from each department was included in the cross-functional teams and they carried the responsibility of ensuring cooperation from their respective departments in line with the corporate environmental policy or/and environmental vision and mission of the firm. From a construction sector perspective, the importance of cross-functional integration on greening is novel and significant (which has not been discussed previously in the construction literature). However, it does conform with the previous findings in other sectors that stress the importance of cross-functional integration for greening the supply chain (Zhu and Sarkis, 2004; Zhu et al., 2007b; 2008c).

4.2.5 Assessing green-related research and development (R&D)

Green-related research and development emerged as an important facilitating green practice, which has not been identified previously in the GSCM literature. However, it was evident from the interviews that green-related R&D was more prominent among Suppliers. The R&D activities by Suppliers were mainly targeted at developing in-house state of the art products and technologies. However, this should not be confused with the green design practices of Suppliers, though both green design and green related R&D pertain to materials design. This is because the former is more from an operational perspective, with the latter being more from a strategic and long-term perspective. In fact, one of the glass manufacturers interviewed was able to develop a patent pending glass window technology for buildings that can convert 90% of the solar radiation falling on its surface to electricity.

In the case of Architects/Consultants, the R&D activities were focussed on developing innovative green design techniques and solutions, though the commitment given in terms of budget allocation (investment in R&D as a percentage share of the annual revenue) was found to differ across interviewed firms. However, for Developers, the emphasis given to R&D was limited, as they feel importing best practices from developed countries and getting ideas from Architects/Consultants as a faster, flexible, reliable and relatively cheaper means to innovate than investing in a full-fledged R&D team. Interestingly, Contractors were of the same opinion as Developers. They too preferred importing best practices from developed countries, though few Contractors were exploring the possibility of joint R&D with Suppliers for developing innovative green products.

The survey results on the extent of implementation of facilitating green practices for each stakeholder are given in Table 4.6. Like core green practices, results show that facilitating green practices are comparatively lower for Developers and higher for Suppliers. The other important observation is that the green related research and development is lower for all stakeholders, except for Suppliers.

Comparing with the findings in other sectors where some of the facilitating green practices were assessed on a similar 5-point scale (1-5) shows that the extent of implementation of EMS and ISO

Table 4.6 Extent of implementation of facilitating green practices by each stakeholder ..

Individual facilitating green practices	Developer Mean	Architect/ Consultant Mean	Contractor Mean	Supplier Mean
Environmental Management Systems (EMS) and ISO Certification is implemented	3.4	4.1	4.3	4.1
Environmental training programs are conducted	3.1	4.1	4.0	4.5
Environmental auditing activities are executed	3.2	3.9	3.7	3.7
Cross-functional integration for greening is achieved	3.3	4.3	3.8	4.1
Green related research and development is conducted	2.6	3.4	2.4	4.6
Overall extent of implementation of facilitating green practices	3.1	3.9	3.6	4.2

**Mean is measured on a scale of 1 (Strongly disagree) to 5 (Strongly agree)*

certification, in general, is higher for the construction sector than sectors such as manufacturing (3.3) (Zhu and Sarkis, 2004) and automobile (3.0) (Zhu and Sarkis, 2006), but comparable to sectors such as power (4.3) and electronics (3.9) (Zhu and Sarkis, 2006). On the other hand, conducting environmental training programs, in general, is lower for the construction sector compared to other sectors such as power (4.4) and electronic (4.2) (Zhu and Sarkis, 2006).

4.3 Summary of findings

This section will recap the overall survey findings. This is important as it can unearth some important observations/patterns that are missed out while assessing each aspect individually. Table 4.7 summarises the survey findings.

The summary statistics concerning facilitating green practices indicate that the extent of implementation of Suppliers emerged to be the highest (mean score of 4.3) with a relatively low SD of 0.6, indicating that implementation is high across most Supplier firms. Conversely, the facilitating practices of Developers emerged to be the lowest (mean score of 3.1) with a relatively high SD of 1.3, pointing to an imbalance in the implementation among different Developer firms. For Architects/Consultants and Contactors, the extent of the implementation was moderate, with mean scores of 3.9 (SD=0.9) and 3.6 (SD=0.9) respectively. In terms of core green practice implementation, Developers emerged as lagging, with the mean scores of all the four constructs

Table 4.7 Extent of implementation of green practices at the construct level

Stakeholder	Developer	Architect/ Consultant	Contractor	Supplier
Green practices	Construct Mean (SD)	Construct Mean (SD)	Construct Mean (SD)	Construct Mean (SD)
<i>Facilitating green practices</i>	3.1 (1.3)	3.9 (0.9)	3.6 (0.9)	4.3 (0.6)
<i>Core green practices</i>				
Green design	3.4 (1.2)	3.8 (1.1)	-	4.5 (0.7)
Green purchasing	3.3 (0.9)	-	3.8 (1.1)	4.1 (1.3)
Green transportation	2.9 (1.3)	3.4 (1.3)	3.6 (1.1)	4.0 (0.8)
Green construction /manufacturing	-	-	3.9 (1.0)	4.30 (0.6)
End of life green practices	2.6 (1.6)	3.3 (1.0)	3.7 (1.0)	-

Construct mean (Scale 1-5) - Average of the individual mean values of items representing that construct

Construct SD (Scale 1-5) - Average of the individual standard deviation of items representing that construct

(green design, green purchasing, green transportation, and end of life green practices) being lower than the other stakeholders. This lag is especially higher for end of life green practices (mean value of 2.6) compared to Architects/Consultants (mean value of 3.3) and Contractors (mean value of 3.7). Furthermore, the high standard deviation for Developers (1.6) for the end of life green practices indicates that perhaps only a few Developer firms have actively started to consider end of life green practices. On the other hand, the core green practices of Suppliers emerged as the most significant among stakeholders for all of the relevant constructs. This relatively higher mean score for the Suppliers could be attributed to the fact that green product/material 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 constructs, with mean scores ranging between 3.3–3.8 and 3.6–3.9, respectively.

The high standard deviation for several constructs ($SD > 1$), point to a lack of consistency in the implementation across firms, with some firms having relatively high-level implementation in

comparison with others. There is a possibility that firm size and firm ownership may have influenced this lack of consistency. This will be explored further in Chapter 10.

4.4 Green practices understood through strategic choice theory, resource and knowledge-based views, and resource-dependence theory

The underlying differences in the extent of implementation of green practices can be understood using various theories, namely resource and knowledge-based views, resource-dependence theory and strategic choice theory. To a great extent, it was evident from the interviews that implementation of green practices was dependent on the firm's resources, both financial and human resources. This is consistent with the resource based and knowledge based views of the firm. According to the resource-based-view (RBV), an organisation's resources can be defined as all assets, capabilities, organisational processes, firm attributes, information and knowledge possessed by a respective firm (Barney, 1991). Similarly, according to the knowledge-based view (KBV) (an extension of RBV), knowledge is the most strategically significant resource of a firm. The proponents of KBV argue that the knowledge-based resources of a firm are socially complex and difficult to copy, and therefore the heterogeneous knowledge bases and capabilities of firms are the major determinants of sustained competitive advantage and superior corporate performance (Grant, 2002). However, firms could use external resources to implement green practices. For example, Developers could develop green building design using Architects/Consultants. Therefore, the willingness of the stakeholders to implement green practices is also dependent on other stakeholders or external resources. In other words, some firms are more resource-dependent than others. This was evident on multiple occasions in the interviews. For example, one of the Developer firms interviewed has given the entire project from design to handover to the Contractor. In this case, the Developer is 100% resource-dependent on the Contractor. Similarly, main Contractors are often too resource-dependent on Subcontractors. In other cases, firms were reluctant to implement green practices with which they do not have the expertise, a reluctance to be dependent on others. From a resource-dependence theoretical perspective (Salancik and Pfeffer 1978), organisations are dependent upon resources provided by outside parties in order to compete (in this case implement green practices). The theory also warrants the need for establishing inter-organizational collaboration

and the establishment of formal and semi-formal linkages with other firms (Ulrich and Barney, 1984) to ensure that strategically critical resources are available.

The other important observation from the interviews is that firms with good knowledge and resources are still reluctant to implement green practices. While this contradicts the resource based and knowledge based views, it can be explained through strategic choice theory. The strategic choice theory emphasises the role of a manager's decisions in organisational outcomes (Child, 1972). In the realm of GSCM, implementing green practices can be seen as a strategic choice by firms to serve their own personal interests.

To summarise, this chapter addresses the first research question in this thesis. As mentioned earlier, the central tenant of GSCM is the extensive, efficient and effective implementation of green practices. Therefore, attaining a thorough understanding of green practices (both core and facilitating), and for each stakeholder individually, is important, since, in total, they determine the life-cycle environmental impact of a construction project and consequently the sector as a whole. In this chapter, first, the various green practices implemented by individual stakeholders (identified mainly through the interviews) were discussed. The findings are of importance since they give practitioners in the UAE and elsewhere a potential stock of green practices that can be adopted by individual stakeholders for greening the construction supply chain. Next, the extent of implementation of these green practices across the sector (captured in the form of a survey questionnaire) was discussed based on the country-wide survey findings. The survey findings are pivotal in understanding the current status of the green practices' implementation in the UAE construction sector. It helps practitioners and policymakers to identify those stakeholders and practices that are lagging others.

Finally, in this chapter, several established/emerging management theories were discussed that offers a plausible basis to explain the behaviour of stakeholders in implementing green practices. Overall, for practitioners and/or policymakers faced with the reality of addressing complex sustainability challenges, the empirical evidence accompanied by general theoretical principles is expected to inform the wider application of green practices in the construction sector.

Chapter 5 – Assessing the Drivers and Barriers Affecting Green Practices' Implementation

While the previous chapter identified, and discussed the broad range of core and facilitating green practices including their extents of implementation, in line with our research question (RQ2), the objective of this chapter is to develop a comprehensive understanding of the underlying drivers (pressures/motives) and barriers (challenges/hindrances) affecting the implementation of these green practices (discussed in Chapter 4). Here also, this chapter will attempt to develop a comprehensive picture by integrating the findings from the interviews, surveys and literature, as well as using established/emerging theories to enhance the generalisation of the findings and to connect them to a larger body of GSCM/green literature.

From a practitioners' and policymakers' perspective, the chapter's findings could reveal important insights such as why some firms implement a multitude of green practices or why the extent of implementation of these practices differs across firms, and could therefore assist them to devise strategies to maximize/leverage the drivers and minimize/eliminate the barriers to promoting sector-wide green practices' implementation.

However, here too, any effects of firm size and ownership on green drivers and barriers are separated to the extent possible and will be discussed separately in Chapter 10. Also, the causal relationships between green drivers and barriers and green practices are also not discussed in this chapter as they are discussed in detail in Chapter 7, though some of them may be discussed passively in this chapter. The following sections will discuss in sequence the various green drivers (external and internal) and barriers (external and internal) identified, including their perceived importance/relevance in influencing the green practices implementation in the construction sector.

5.1. Assessing the drivers affecting green practices' implementation

As stated before, green drivers or pressures/motives affecting the implementation of green practices can be classified as external and internal green drivers depending on the source of origin of these pressures/motives. As seen in previous studies, this categorisation is important as

it gives better manageability for firms to leverage green drivers (Walker et al., 2008; Walker and Jones, 2012; Brik et al., 2013).

The presentation of the findings related to each of these external and internal drivers is in such a way that details related to each green driver including its relevance/non-relevance for each stakeholder (identified from the interviews) and perceived importance/relevance (captured through the country-wide survey) is discussed in sequence. Also, several management theories, both emerging and established are used to develop a deeper, broader and simplified understanding of these green drivers.

5.1.1 Assessing external green drivers

The qualitative interviews identified the following green drivers: government green-related regulation, supply chain stakeholder pressure, competitor pressure and buyer/end-consumer pressure. While these identified drivers are in accordance with the generic GSCM literature and can be explained from an institutional theoretical perspective, some of these green drivers such as competitor pressure and buyer/end-consumer pressure have not been discussed previously in the construction literature and therefore add to the novelty of this study.

On the contrary, the other green drivers discussed in the generic and construction sector literature such as pressure from non-government organizations (Qi et al., 2010; Zailani et al., 2012) and government incentives and support (Liu et al., 2012; Hsu et al., 2013) were not identified as green drivers in the UAE construction sector. The findings from the additional interviews conducted with a leading non-government organisation (NGO) and regulatory bodies to understand the non-relevance/non-existence of this driver is discussed later in this chapter.

The following subsections will discuss in sequence each of the relevant external drivers including their perceived importance/relevance.

5.1.1.1 Impact of government green-related regulation

Government green-related regulation was identified as an important driver of green practices in the UAE construction sector. This is line with the previous findings in both construction (Adetunji et al., 2008; Qi et al., 2010) and in other sectors (Zhu and Sarkis, 2006; Ben Brik et al., 2013) that reported government regulation as one of the important drivers of green practices. This was not

surprising given that government regulation leaves no option for a firm but to comply with it or exit the market.

The various aspects of government green-related regulation identified from the interviews include government green building regulations and associated non-compliance fines and penalties, landfill tax and associated fines for environmental accidents. However, it was evident from the interviews that it is the Developers and Contractors who are mainly facing these regulations. In fact, none of the Suppliers interviewed identified government regulation as a driver for their green practices and rightly so, because they do not face any green-related regulation in the UAE. Architects/Consultants were found to face these regulations indirectly as they are passed on to them by Developers.

With regards to government green building regulation, any new project in the emirate of Dubai or Abu Dhabi (which covers 90% of all construction projects in the UAE) must abide by the green building regulations in their respective emirate. This includes the municipal green building regulations in the emirate of Dubai introduced in 2011; the ESTIDAMA pearl rating system for buildings in the emirate of Abu Dhabi introduced in 2010, and the EHS Trakhees in Free Zones introduced in 2006; all three are modelled around LEED (Leadership in Energy & Environmental Design). This is similar to the mandatory green building standards in US⁹ and UK¹⁰

For Developers, the UAE green building regulations cover several aspects such as those pertaining to material selection, design aspects that include natural ventilation, lighting, water and energy consumption and use of renewable energy. Failure to comply with the green building regulations implies Developers will not be granted approval from the land department for operation. This shows that green building compliance is not an option but an obligation for Developers. This was constantly reflected in the statements of the interviewed Developers, who acknowledged the importance of complying with green building regulations. However, a concern highlighted by the Developers is the lack of unified green building regulations in the UAE. The three building regulations present in the UAE, though related, have several subtle differences. Therefore,

⁹ <https://www.epa.gov/smartgrowth/green-building-standards>

¹⁰ https://www.designingbuildings.co.uk/wiki/Environmental_legislation_for_building_design_and_construction

according to the respondents, complying with different regulations in different projects is an unwieldy task. In the words of an interviewee:

“A unified federal level framework would be ideal for greening the sector than several standalone frameworks”

On the positive side, respondents also acknowledged the overwhelming influence of these regulations in changing the status quo of the Developers in the UAE. For instance, any noncompliance would delay/deny the approval to start the construction activities as well as post-construction municipal approval for occupancy. Moreover, given that these green building regulations are modelled around LEED (though not as stringent as LEED), Developers are motivated to go beyond the regulation to achieve LEED certification, which is an internationally recognised green building certificate.

In the case of Contractors, according to the respondents, one of the regulations they face (only in the emirate of Abu Dhabi as specified by ESTIDAMA) is that they must achieve 50% onsite waste aversion from the landfill. In addition, Contractors in both Dubai and Abu Dhabi have to pay landfill charges (charged for each truckload), though the majority of respondents acknowledged that these landfill charges are too nominal¹¹ to affect any significant behavioural changes in Contractors. Finally, Contractors highlighted the fines for environmental accidents such a spilling of hazardous materials, breakage of underground pipes and contaminating the surrounding flora and fauna had made them more conscious of implementing green practices. This is in accordance with previous studies that suggested that environmental fines and penalties have led to more respectful attitudes towards the environment among contractors (Tam et al., 2006; Qi et al., 2010).

Next, the perceived importance/relevance of government regulation in influencing green practices based on the results from the country-wide survey are discussed.

Table 5.1 shows the results of the survey. Suppliers are excluded since government regulation was not identified as a driver of green practices by Suppliers.

¹¹ Compared to other countries such as Hong Kong (Jaillon et al., 2009)

Table 5.1 Perceived importance of government green regulations by each stakeholder

External driver	Developer Mean	Architect/Consultant Mean	Contractor Mean	Supplier Mean
Pressure from government green-related regulations and associated fines/penalties	3.3	2.1	3.7	-

**Mean is measured on a scale of 1 (no influence) to 5 (extremely high influence); '-' indicate the item is not relevant for the stakeholder.*

As seen in the table, government regulation is perceived as a moderate driver of green practices by Developers and Contractors, though its importance/relevance is slightly higher for Contractors (M=3.7) than Developers (M=3.3). This moderate influence is not surprising given that government regulation is relatively new in the UAE and is not as stringent as in other countries or sectors. Moreover, the geographic coverage of the survey includes all seven emirates and not just limited to respondents from Dubai and Abu Dhabi, where these regulations apply. The respondents from other Emirates were expected to rate government regulation low since they do not have any regulation. Also, not unexpectedly, Architects/Consultants rated this very low, since they do not face any direct regulation.

The findings show that there is still scope for government to enact effective policies, increase stringency and increase the coverage to include other stakeholders such as Architects/Consultants and Suppliers. For instance, studies in other sectors have shown government green regulation as a driver of green practices is rated as high as 4.5 on a similar 5-point scale (Zhu and Sarkis, 2006).

From a theoretical perspective, this can be explained through the lens of coercive isomorphism, where a powerful constituency such as government imposes certain patterns on the organisation (DiMaggio and Powell, 1983). The findings to a great extent conform to the previous GSCM studies in other sectors that reported governmental regulatory bodies as powerful institutions that can coercively influence the environmental actions of organisations (Zhu et al., 2011). Sarkis et al. (2011) highlighted how well in developed countries such as the US, coercive pressures through laws and regulations improved green practices.

5.1.1.2 Impact of supply chain stakeholder pressure

Stakeholder pressure is the coercive pressure faced by one supply chain stakeholder from another. Developers were identified as the main source of this pressure in the interviews since they were responsible for the concept and initiation of new construction projects. The extent of green outcomes desired by the Developer would, therefore, coerce other supply chain stakeholders to implement green practices. In the words of one interviewee,

“If it is environmental performance, the primary driver is the Developer, otherwise neither the Contractor nor the Consultant will bother to implement it.”

This echoes the previous findings of Qi et al. (2010), who found stakeholder pressure from Developer/Client as one of the major drivers of green practices in the Chinese construction sector.

The majority of the Architects/Consultants interviewed acknowledged that they faced strong coercive pressure from Developers. This is because the government green building requirements and Developers’ own environmental requirements (if any) are passed on to Architect/Consultants contractually for execution. This was stressed by Architects/Consultants during interviews as a key driver for them to implement green practices, as any failure to do so may lead to them not winning the project in the first instance, being expelled from the project or blacklisted from future projects. This was easy to comprehend, given that Developers are the ones who sit on top of the supply chain hierarchy and have the power to control the downstream supply chain. However, in a few rare cases, Developers who have given the entire design and build responsibility to the main Contractor, wherein which the coercive pressure faced by the Architect/Consultant comes from the Contractor. Also in another rare case, a Developer, wherein, the Consultant is appointed as their representative of the project, who then holds the same power as the Developer to coerce other stakeholders, including the main Contractor, in implementing green practices.

Developers were also found to exert similar pressure on Contractors too to implement green practices. Also, Architects/Consultants were found to exert pressure on Contractors by means of performing background checks on the green expertise of Contractors before giving their technical

approval to Developers for awarding contracts. Further, Architects/Consultants were found to perform periodic check/monitoring of Contractors to ensure their adherence to green specifications during the construction process. Both Architects/Consultants and Contractors, in turn, were found to pressurise entities lower down in the hierarchy such as Subcontractors and Suppliers. For instance, Suppliers, face pressure from Consultants and Contractors to meet the green material/technology requirements as specified in the tender documentation or at times over and beyond what was required in the tender requirements as part of their environmental commitment. Similarly, Contractors were found to conduct periodic checks on Subcontractor's green practices. The findings also included a small number of Contractors who pressurised their Subcontractors and Suppliers to sign the United Nations Global Compact agreement. In generic terms, the coercive pressure can be seen as flowing down the hierarchy from Developers onto the Suppliers, with even Subcontractors in some cases being seen to coerce their Suppliers to implement green practices. Robin and Poon (2009) highlighted the existence of similar hierarchical pressure from Developer to Supplier in the Hong Kong construction sector.

Though theoretically, other stakeholders can pressurise Developers or upstream stakeholders, this was not found in the UAE construction sector. It was evident from the interviews that other stakeholders in the supply chain were found not to be in a position of power to pressurise Developers to implement green practices. In the words of one Architect/Consultant:

“We will try to convince the Client/Developer about the possibilities of implementing green practices; however, there is a limit to which we can push”

The survey results on the perceived importance/relevance of stakeholder pressure in driving green practices across the sector are given in Table 5.2.

Table 5.2 Perceived importance of stakeholder pressure by each stakeholder

External driver	Developer Mean	Architect/ Consultant Mean	Contractor Mean	Supplier Mean
Pressure from supply chain stakeholders	1.9	4.0	3.0	3.0

**Mean is measured on a scale of 1 (no influence) to 5 (extremely high influence); ‘-’ indicate the item is not relevant for the stakeholder.*

As expected, Developers face the lowest stakeholder pressure (M=1.9). As stated previously, this could well be because other stakeholders in the supply chain were found not to be in a position of power to pressurise Developers to implement green practices. Not surprisingly, the mean score of Architect/Consultant is high (M=4.0). The moderate stakeholder pressure perceived by Contractor (M=3.0) and Suppliers (M=3.0) shows that the intensity of this pressure is getting lower as it moves down the hierarchy from Architects/Consultants onto Suppliers.

From a theoretical perspective, this again can be explained through the lens of coercive isomorphism. Stakeholders who have the power to control other stakeholders, especially their downstream supply chain stakeholders, were found to exert pressure on them to implement green practices. This conforms to previous GSCM studies in another sector, where stakeholder pressure was found to be a significant driver of green practices (Yu et al., 2014; Zhu et al., 2008).

5.1.1.3 Impact of competitor pressure

Competitor pressure was also found to drive green practices across stakeholders. From a construction sector perspective, this is a novel finding, as none of the previous studies has reported competitor pressure as a driver of green practices. In the case of Developers, it was evident that the increasing number of LEED certified projects emerging in the UAE (from 1 in 2011 to more than 900 in 2015 according to LEED, 2015) is putting pressure on Developers to develop similar projects. The Architects/Consultants and Contractors too were found to face competition, especially from overseas firms that have entered UAE with advanced green knowledge/capabilities (as reflected in the 25% increase in foreign direct investment in the UAE's construction sector in the last few years reported by TFG, 2015). Also with increasing green requirements from Developers, both Architects/Consultant and Contractors acknowledged the fact that they need to implement green practices to stay competitive in the market, otherwise they risk losing market share to competitors. For Suppliers, competitor pressure was not found to be a strong green driver, which is reasonable, because the competition in itself is low due few local Suppliers in the UAE¹². However, a small number of Supplier respondents do acknowledge

¹² https://www.zawya.com/uae/en/company/Pro_Business_Directory-13010586/

that they face pressure to come up with innovative green products due to the inflow of green materials from foreign countries (imports).

The survey findings on competitor pressure are given in Table 5.3.

Table 5.3 Perceived importance of competitor pressure by each stakeholder

External driver	Developer Mean	Architect/Consultant Mean	Contractor Mean	Supplier Mean
Pressure from competitors	3.2	3.1	2.8	2.8

**Mean is measured on a scale of 1 (no influence) to 5 (extremely high influence); ‘-’ indicate the item is not relevant for the stakeholder.*

As seen in the table, Developers were found to face the highest competitor pressure (M=3.2) among the stakeholders, followed by Architects/Consultant (M=3.1). As evidenced from the interviews, the comparatively high stakeholder pressure perceived by Developers could well be due to the increasing number of LEED certified projects, and for Architects/Consultants, it could be due to increasing number of foreign Architectural/Consulting firms starting operation in the UAE. However, the pressure is relatively low among Contractors (M=2.8) and Suppliers (M=2.8). While this was expected for the Suppliers (because there are few only Suppliers in the UAE), the low mean score for Contractors was to some extent surprising given most interviewees stressed the significance of competitor pressure in driving their green practices.

Overall, there is evidence that competitor pressure is to some extent driving green practices in the UAE construction sector. However, compared to other sectors, the perceived importance/relevance of competitor pressure in driving green practices is relatively low. For example, previous studies that assessed the perceived importance/relevance of competitor pressure in driving green practices on a similar 5-point Likert scale found the influence (mean score) to be 4.4, 4.2 and 4.1 for the automobile, power and electronic sectors respectively. Given that the UAE construction sector is relatively new to green practices, the influence of competitor pressure is expected to become greater as the sector matures further.

From a theoretical standpoint, competitor pressure can be explained through the lens of mimetic isomorphism. According to this theory, firms are under constant mimetic pressure to imitate/mimic the actions of their successful competitors in the industry in order to either follow

their success or in an attempt to avoid losing their competitive advantages (DiMaggio and Powell, 1983). The interview findings to some extent conform to this theory since the study found several instances of firms trying to copy their successful competitors.

5.1.1.4 Impact of buyer/end-customer pressure

Since buyer or end-customer direct engagement is with the Developer only, buyer or consumer pressure to implement green practices was found to be relevant only to Developers and not to other stakeholders. However, compared to other pressures, this pressure was found to have limited influence on the green practices of the interviewed Developers. Some of the reasons highlighted by interviewees include a low level of environmental awareness on behalf of the UAE investors/buyers especially with regards to the cost-saving and health benefits of green buildings. According to respondents, this is because a large percentage of buyers in the UAE is of South Asian origin, where issues related to the environment are just emerging. In fact, this was echoed in our interviews with the end-users of the building as well as with the real estate agents. In all cases, there was a clear lack of awareness about green buildings and their potential benefits. For instance, the two end-users interviewed highlighted that they either bought or leased the apartment without actually knowing the building was LEED gold certified. Similarly, the interviewed real-estate agents who are dealing with the sales/leasing of green buildings were found to make no effort whatsoever in promoting green buildings. This is in stark contrast to the previous findings in other sectors where more than 80% of the consumers were willing to pay more for green products (Zhu and Geng, 2000). The other reason identified for lack of consumer pressure is the limited ability of buyers (again mainly South Asian origin) to pay a premium for green/LEED certified apartments given their lower socio-economic strata. The other main concern echoed by most of the respondents is the relatively inexpensive/subsidised water and electricity prices in the UAE. As a result, energy and water cost saving potential over the apartment life cycle for the end-user is minimal, as the costs are already low; therefore, there is financially less incentive for buyers to invest and consequently less consumer pressure. Moreover, the transient expatriate population, which is more than 80% of the UAE population, is investing in buildings including green ones to make short profits rather than to achieve the life-cycle benefits. However, on a few occasions, respondents acknowledged some extent of

consumer pressure from foreign buyers, especially from US and UK in the high-end spectrum, as they were found to show interest in the sustainability ratings of the building. Similarly, one Developer respondent highlighted that institutional investors who are looking to buy their publicly traded shares are looking for their environmental initiatives among other factors.

The survey findings on consumer pressure are given in Table 5.4.

Table 5.4 Perceived importance of buyer/end-customer pressure by Developer

External driver	Developer Mean	Architect/Consultant Mean	Contractor Mean	Supplier Mean
Pressure from consumers	1.9	-	-	-

**Mean is measured on a scale of 1 (no influence) to 5 (extremely high influence); '-' indicate the item is not relevant for the stakeholder.*

The survey findings to a good extent conform to the interview findings that consumer pressure is not as prevalent in the UAE construction sector as in some other sectors. For instance, consumer pressure as a driver of green practices assessed on a similar scale (5-point scale) was found to be well above 4.0 across diverse sectors (Zhu and Sarkis, 2006). Still, the influence of consumer pressure on the green practices of Developers has not been discussed previously in the construction literature and therefore adds to the novelty.

From a theoretical standpoint, consumer pressure (or lack thereof) can be explained through the lens of normative isomorphism (DiMaggio and Powell, 2013). According to this theory, firms face normative pressure from external stakeholders such as customers and non-governmental organisations who have a vested interest in the firm (Hsu et al., 2013). However, the findings from this study are in stark contrast to some of the GSCM findings in another sector, where they found the normative pressure to play a significant role in the green practices of manufacturers (Zhu et al., 2013; Hsu et al., 2013).

As normative pressures have been discussed, it is important to report the pressure exerted by non-governmental organisations (NGOs). However, this was rarely reported by respondents as a driver of green practices in the UAE. To explore further, one of the leading NGOs in the UAE construction sector who is trying to promote environmental/green practices in the sector was interviewed. When probed regarding their lack of ability to exert pressure on supply chain

stakeholders to implement green practices, the interviewee acknowledged the fact that, unlike other countries such as China and Malaysia, where non-government organisations (NGOs) have a strong normative influence on Developers and other stakeholders (Abidin, 2010; Qi et al., 2010), NGOs do not enjoy any legal backing in the UAE and moreover, their activities are closely scrutinized. Further, it was found that there are very few environmental NGOs operational in the UAE. Overall, it shows that normative pressure is not as prevalent in the UAE as in other countries and sectors.

5.1.2 Assessing internal green drivers

The qualitative investigation identified the following internal drivers of green practices: the environmental commitment of firms, enhance reputation/brand image, to reduce costs and enter foreign markets. This is largely in accordance with the GSCM literature, which states that firms implement green practices as part of their own environmental commitments and/or to achieve clearly stated business benefits (Seuring and Muller, 2008; Walker and Jones, 2012). From a construction sector perspective, though environmental commitment has been identified by several studies in the construction sector (Ofori, 2000; Qi et al., 2010; Zhang et al., 2011), a limited number of studies have discussed the desire to achieve business benefits as a driver of green practices. Therefore, understanding these green drivers (enhance reputation/brand image, to reduce costs and enter foreign markets) significantly adds to the body of GSCM literature in construction.

The following sub-sections will discuss in sequence each of the relevant internal green drivers including their perceived importance/relevance.

5.1.2.1 Assessing firms' 'environmental commitment' as a green driver

Environmental commitment or commitment to protect the environment was identified as a significant driver of green practices across all stakeholders. In the case of Developers, it was evident from the interviews that environmental commitment was one of the reasons for firms to implement green practices beyond the mandatory green building regulations, such as their effort to achieve LEED silver/gold certification. Respondents reasoned this commitment due to the values of their owners and/or top management. For instance, most Developers interviewed had

clearly outlined comprehensive corporate environmental policies and procedures that demonstrated their environmental commitment. These policies and procedures were found to include guidelines on lowering pollution, using natural resources, climate change based investment decisions, environmental training, and meeting stakeholder's environmental expectations, with the key statements in some cases reading as "committed to protecting the environment and ensuring sustainability of our communities" and "committed to carrying out all activities in an environmentally sustainable way".

Similarly, other stakeholders also demonstrated environmental commitment. In most cases, these commitments were clearly stated and communicated to their employees and external stakeholders, either through environmental vision or mission statements and/or through corporate environmental policy. For instance, the majority of the Suppliers interviewed had the term "sustainability" integrated into their corporate vision and mission statements, again a clear demonstration of commitment to environmental protection. Few Suppliers interviewed had internal employee awareness programs on climate change and carbon emissions. Similarly, close to half of the Suppliers interviewed had annually published sustainability reports. Two Suppliers interviewed had basic environmental awareness training being imparted during employee induction and one Supplier had an integrated carbon management strategy communicated to their employees with each department having quantifiable targets to achieve.

In the case of Architects/Consultants and Contractors, the environmental commitment is largely seen among foreign firms because they must comply with the environmental policies of their headquarters. Also, environmental commitment is seen among joint venture firms, in which the local partner was found to inherit the environmental vision and mission of their foreign partner. This variation due to size and ownership in environmental commitment for all stakeholders will be explored in depth in chapter 10.

Also, to a varying extent, all stakeholders interviewed highlighted the importance of having the support of top, senior and operational managers to impart changes in organisational policies to foster a green culture.

The survey findings on environmental commitment are given in Table 5.5.

Table 5.5 Perceived importance of environmental commitment by each stakeholder

Internal driver	Developer Mean	Architect/ Consultant Mean	Contractor Mean	Supplier Mean
Environmental commitment of firms	2.9	3.6	3.6	4.5

**Mean is measured on a scale of 1 (no influence) to 5 (extremely high influence)*

As seen in the table, the results show that the environmental commitment is high for Suppliers (M=4.3), while moderate for Architects/Consultants (M=3.6) and Contractors (M=3.6) and relatively low for Developers (M=2.9). The low environmental commitment of Developers is a concern given that they are the ones who initiate the green projects. However, the environmental commitment of other stakeholders is encouraging for the sector, especially that of Suppliers, which was found to be higher than the environmental commitment found in the manufacturing sector (M=3.8), assessed on a similar 5-point Likert scale (Zhu and Sarkis, 2004).

Overall, the findings of this study show that firms with stronger environmental commitment are better motivated to implement proactive green practices. This echoes the previous findings in the construction sector literature (Ofori, 2000; Qi et al., 2010; Zhang et al., 2011) and other sectors (Zhu and Sarkis, 2004; 2006).

From a theoretical standpoint, the environmental commitment of firms can be understood using the new institutional theoretic perspective (Scott, 2001), Cultural-cognitive (socio-cultural responsibility) isomorphism. According to this theory, the environmental commitment of firms, generally a voluntary obligation to society, can be viewed as a rational desire to embrace environmental practices that are consistent with the obligations and values of the society in which they function (Hsu et al., 2013). The findings in this study are line with the GSCM findings in other sectors, which found socio-cultural responsibility to have a significant effect on green supply chain practices (Preuss, 2001; Hsu et al., 2013).

5.1.2.2 Assessing ‘enhance green reputation/brand image’ as a green driver

As stated earlier, firms’ internal drive to implement green practices may not be driven entirely due to environmental commitment but also to achieving business advantages. One of the business drives to implement green practices identified from the interviews is the desire to enhance reputation/brand image. In the case of Developers, enhancing reputation/brand image

through green practices was seen as a means to attract foreign investors (as most Developers interviewed were publicly traded firms), attract foreign buyers and fetch higher selling prices. Respondents also acknowledge that enhanced green reputation and brand image would improve their relationship with government bodies and also help sell their projects faster. Enhancing reputation is also seen as a means for risk mitigation. In the words of one of the Developer interviewee:

“Sustainability is considered by our company to avoid reputational risk as well as to achieve reputational gains”.

Overall, the Developer findings echo the previous findings in the literature that found Developers in the US and China are using green practices to improve their brand image (Zhang et al., 2011). It was also observed in the interviews that the Developers who are keen on enhancing green reputation/brand image made a concerted effort to deal with reputed Architects/Consultants and Contractors. This was also reciprocated in the response of Architects/Consultants and Contractors, who acknowledged the relevance of green brand image for winning projects from Developers to gain market share in this fast-emerging green market. For instance, for one of the interviewed Contractors, the significant media coverage and recognition for their waste reduction efforts resulted in many Developers approaching them for business. In the case of Suppliers, almost all interviewees highlighted that it is pivotal for them to improve green reputation/brand image by implementing green practices, their rationale being to increase exports and convince local Architects/Consultants to include their products in the tender specifications and thereby to gain market share.

The survey findings on enhance green reputation/brand image as a driver are given in Table 5.6.

Table 5.6 Perceived importance of ‘enhance green reputation/brand image’ by each stakeholder

Internal driver	Developer Mean	Architect/Consultant Mean	Contractor Mean	Supplier Mean
To enhance green reputation/brand image	2.8	3.6	3.7	4.2

**Mean is measured on a scale of 1 (no influence) to 5 (extremely high influence)*

The pattern of results is similar to that of environmental commitment. As seen in the table, the results show that enhance green reputation/brand image of Suppliers is high (M=4.2), while it is moderate for Architects/Consultants (M=3.7) and Contractors (M=3.7) and relatively low for Developers (M=2.8). The low desire to improve green reputation/brand image of Developers is again a concern. The survey results, except for Developers, compares well with the survey findings of Liu et al. (2012), who on a comparable 5-point scale received a mean score of 3.5 in the Chinese construction sector. However, comparing with other sectors, the driver is relatively lower. For instance, enhance the green image as a driver of green practices for the automotive, power and electronic sectors (one a similar 5-point Likert scale) was found to be 4.6, 4.3 and 3.9 respectively (Zhu and Sarkis, 2006).

From a theoretical stance, the strategic choice theory offers a plausible basis for explaining the desire to enhance green reputation/brand image as a driver of green practices. The theory emphasises the role of a manager's decisions in organisational outcomes (Child, 1972). In the realm of GSCM, implementing green practices can be seen as a strategic choice by respondents to improve brand image, attract investors with a sustainability focus, achieve a high valuation of stock price, increase profitability, and counter any environment-related reputational risks. For instance, one of the Developers interviewed highlighted that it was a strategic decision to pursue LEED certification, because, in any case, they still had to meet the government's green building regulations, which (as mentioned earlier) are based on a similar framework to that of LEED. Similarly, other stakeholders also highlighted that it was a strategic choice to be involved with prestigious green projects, as they would be good references for their future projects.

5.1.2.3 Assessing 'cost reduction' as a green driver

A cost reduction (from green practices) as a driver, it is important to point out that for a construction project, this is possible either during the construction phase (relevant to Contractors/Subcontractors) and/or during the use/operational phase (in the form of energy, water, and other savings that accrue to owners/tenants). This implies cost saving as a driver is not relevant for Architects/Consultants. With Developers, operational cost saving emerged to be less of a driver. The logic as per the respondents is simple. Most interviewed Developers sell their property instead of leasing it to tenants. Since most projects are started with the intent to be

sold off (in fact most sell off-plan before the projects start), respondents highlighted that they have less incentive and motivation to implement green practices that achieve life cycle cost benefits since the sole beneficiary of such practices is the end-user. This narrow mindset is fuelled by the fact that Developers are unable to fetch higher selling prices to get a share of some of the potential life cycle cost benefits enjoyed by the end user. However, intent from Developers was observed on a few occasions where they themselves are the owner of the buildings and to some degree in situations where they are responsible for the maintenance of the common areas such as corridors and lobbies (and consequently responsible for related expenses including water and energy expenses) after they sell the apartment units. To generalise, Developers who initiate projects with the intent to sell them off are less concerned with cost reduction efforts compared to Developers who intend to own and lease the building. For Architects/Consultants, cost reduction as a driver of green practices is not relevant since they are not directly involved in the financial matters of the project.

In the case of Contractors, cost saving was found to be a significant driver for most of the Contractors interviewed. Some of the motivating factors identified from the interviews include a reduction in waste management costs such as landfill charges, related transportation costs to landfill, and significant savings in labour costs and project completion time. For example, one of the interviewees from a large UK-based Contractor reported savings of £0.15 million from a single project through green construction practices. Cost reduction was also found to motivate the green practices of Suppliers. Several Suppliers interviewed acknowledged that the ability to save material, water and energy expenses is one of the motivating factors to implement green practices. However, upfront investment costs such as investment in (imported) green manufacturing equipment and annual maintenance of equipment was highlighted as a challenge in the overall cost reduction efforts.

The survey findings on cost reduction as a driver of green practices are given in Table 5.7.

As seen in the table, cost reduction is low for Developers (M=2.0), moderate for Contractors (M=3.5) and high for Suppliers (M=4.1). The results to a large extent echo the interview findings. Apart from some passive mentions in the construction literature (Adetunji et al., 2008) and in other sectors (Ben Brik et al., 2013), there do not appear to be any studies in any sector that have

assessed and discussed cost reduction as a driver of green practices in such detail as in this section, and therefore adds to the novelty of this study.

Table 5.7 Perceived importance of cost reduction by each stakeholder

Internal driver	Developer Mean	Architect/Consultant Mean	Contractor Mean	Supplier Mean
To reduce costs	2.0	-	3.5	4.1

**Mean is measured on a scale of 1 (no influence) to 5 (extremely high influence); '-' indicate the item is not relevant for the stakeholder.*

From a theoretical standpoint, the findings can be explained through the lens of transaction cost economic theory (Williamson, 1981). Investment in green buildings can be seen as an internal transaction for Developers, with the transaction cost benefits being the operational cost savings from utility bill costs and maintenance costs. Similarly, for Contractors and Suppliers, investment in green construction/manufacturing equipment/technology can be seen as an internal transaction and the potential cost savings achieved from reduced labour hours, waste minimization, recycling, reduction in water and energy consumption can be seen as transaction cost benefits. In a respondent's words:

"Any capital expenditure has to have a good return on investment, i.e., it must pay for itself within few years"

5.1.2.4 Assessing 'enter foreign markets' as a green driver

The relevance of this driver was seen across all stakeholders interviewed. Developers, particularly large ones, acknowledged that they are targeting foreign markets, especially in the US and UK, and therefore are implementing green practices to comply with foreign government regulations. The green/environmental regulation of foreign governments in western/developed economies was found to be more stringent than those in the developing/emerging economies such as the UAE. Moreover, respondents acknowledged the importance of achieving green credentials such as LEED gold/platinum certification, at least for a small number of projects, for impressing/convincing foreign clients/ investors and/or potential Developers to partner with them. For example, one of the Developers which was getting 20% of its revenues from US based

projects was found to be the most engaged in green practices among all the interviewed Developers.

Similarly, in the case of Suppliers, green practices were found to be extensive among those who have exported to foreign markets. For instance, one Supplier interviewed who had exports to 54 countries including the US and UK was found to implement extensive and efficient green practices. In the case of Architects/Consultants and Contractors, however, the motivation for greening provided by this (entry to foreign markets) factor was found to vary as per the nature of their ownership: while foreign-owned firms were found to use UAE as a base and operate in neighbouring countries such as Qatar and Saudi Arabia, and which therefore required LEED certification level capabilities (in order to be competitive), locally owned firms offered services predominantly locally and did not require green capabilities beyond those required by the regulators. The difference regarding ownership will be discussed further in chapter 10. Both Architects/Consultants and Contractors acknowledged the fact that participation in global tenders has influenced their green practices.

The survey findings on entering the foreign market as a green driver are given in Table 5.8.

Table 5.8 Perceived importance of entering foreign market by each stakeholder

Internal driver	Developer Mean	Architect/ Consultant Mean	Contractor Mean	Supplier Mean
Enter foreign market	2.8	3.6	3.3	4.2

**Mean is measured on a scale of 1 (no influence) to 5 (extremely high influence)*

Not surprisingly, the mean score of Suppliers was found to be the highest (M=4.2) as most of the Suppliers are exporting to foreign countries that have stringent environmental policies and regulation. The moderate scores for Architects/Consultants and Contractors could well be due to the variation in motivation due to firm size and firm ownership. For Developers, the relatively low score could be due to the difference in firm size. However, this will be explored further in chapter 10.

Previously, none of the studies in the construction sector that have discussed or even mentioned ‘enter foreign markets’ as a driver of green practices and therefore the findings here add to the

GSCM literature in the construction sector. Also, the results, except for the Developers, are comparable with other sectors. For instance, comparable measure (sales to foreign customers) as a driver of green practices for the automotive, power and electronic sectors (one a similar 5-point Likert scale) was found to be 4.3, 3.9 and 3.7 respectively (Zhu and Sarkis, 2006).

From a theoretical standpoint, this too can be explained from the premises of strategic choice theory. This is because entering foreign markets can be viewed as a strategic choice by firms to increase market share.

Thus far, all the relevant external and internal green drivers affecting green practices in the construction sector have been identified, assessed and discussed. Next, the various barriers to green practices and the perceived importance/relevance of these barriers for each stakeholder will be discussed.

5.2. Assessing the barriers affecting green practices' implementation

As stated previously, green barriers or challenges affecting the implementation of green practices can be classified as external or internal green barriers depending on the source of origin of these barriers/challenges. Like green drivers, this categorization is important as it gives better manageability for firms to minimise/eliminate the adverse effects of green barriers (Walker et al., 2008; Walker and Jones, 2012; Brik et al., 2013).

Like the previous section on green drivers, the presentation of findings related to each of these external and internal barriers is in such a way that details related to each green barrier including its relevance/non-relevance for each stakeholder (identified from the interviews) and perceived importance/relevance (captured through the country wide survey) is discussed in sequence. Also, several management/organisational theories, both emerging and established, are used to develop a rich understanding of these green barriers.

5.2.1 Assessing external barriers

The qualitative investigation identified the following green barriers: shortage of green professionals, shortage of green suppliers, lack of stakeholder collaboration, and tight and inflexible stakeholder deadlines. Among the barriers identified, tight and inflexible stakeholder

deadline has not been identified previously in the construction literature and therefore adds to the novelty of this study.

The following subsections will discuss in sequence each of the relevant external green barriers including their perceived importance/relevance.

5.2.1.1 Impact of shortage of green professionals

The shortage of green professionals was acknowledged as a barrier by all stakeholders, though the relevance varied across stakeholders. The general consensus across interviewed Developers and other stakeholders were that there is a lack of quality academic/training programs in the UAE offered in areas such as sustainable architecture/construction and construction supply chain management at local universities, colleges and training centres. The respondents were also of the view that the green certification opportunities such as ESTIDAMA (in Abu Dhabi) and EHS-Trakhees (in Dubai), provided by the local government authorities to address this shortage, were not enough to plug the shortage of green professionals in the UAE.

According to Architects/Consultant and Contractors, the number of personnel required for green projects is much higher than that of conventional projects. However, based on the interview findings, it can be generalized across stakeholders that large firms view this as less of a barrier (because they have the financial resources) as they were found to offer attractive packages to hire certified green professionals from countries such as the UK, US and Germany as well as certify their own employees. For Architects/Consultants and Contractors, the variance was also found based on ownership. For instance, many of the interviewed foreign Architects/Consultants and Contractors were found to shift employees from head office or other branches to the UAE on a temporary project basis to address the shortage of green professionals. The extent of variance based on size and ownership will be explored in detail in chapter 10. However, in the case of Suppliers, this was found to be less of a barrier, since green practices for Suppliers is more technology/equipment dependent and less complex as well as the fact that employees are well trained through in-house training programs on green related aspects. Also, unlike other stakeholders, Suppliers acknowledged the fact that they had the flexibility to hire

green/sustainability professionals from any manufacturing sector, and therefore shortage of green professionals is less of a barrier.

The survey findings on the shortage of green professionals as a barrier of green practices are given in Table 5.9.

Table 5.9 Perceived importance of shortage of green professionals by each stakeholder ..

External barrier	Developer Mean	Architect/ Consultant Mean	Contractor Mean	Supplier Mean
Shortage of green professionals	3.4	2.7	3.2	2.9

**Mean is measured on a scale of 1 (no influence) to 5 (extremely high influence)*

As seen in the table, the barrier is relatively high for Developers (M=3.4) followed by Contractors (M=3.2). This is a concern given that Developers initiate the green projects, and Contractors are the ones who do the actual construction. Any hindrances/challenges faced by both Developers (M=3.4) and Contractors (M=3.2) will have a ripple effect (dampening effect) on the green practices of other supply chain stakeholders. This echoes the previous findings in the literature, which highlight shortage of green professionals as a major barrier to implementing green standards in buildings because green buildings require complex construction processes and complicated techniques (Zhang et al., 2011). Further, Jaillon et al. (2009) reported lack of skilled workers as a barrier to implementing prefabrication practices for Contractors in the Hong Kong construction sector.

While the relatively low mean score for Suppliers is expected because of their lower reliance on skilled professionals (more technology/equipment dependent), the low score for Architects/Consultants could well be due to the variance in firms due to their size and ownership. Overall, shortage of green professionals is a barrier that needs attention, but not an overarching barrier given that the perceived importance ranged from moderately low to moderate across stakeholders.

From a theoretical stance, shortage of green professionals in the UAE as a deterrent to the implementation of green practices can be explained on the basis of the knowledge-based view. As highlighted earlier, according to the theory, knowledge is the most strategically significant

resource of a firm. The shortage of green professionals implies that the firms are expected to lack the heterogeneous knowledge bases and capabilities required for the implementation of green practices. Firms, therefore, are required to build this knowledge base by training existing employees and/or hiring employees with green expertise or outsourcing their green activities.

5.2.1.2 Impact of shortage of local green suppliers

The shortage of green suppliers being a barrier to green practices was acknowledged by all stakeholders but to a varying extent. It was evidenced from the interviews that for both Developers and Contractors, the reluctance in implementing green practices is because most green materials required for their implementation are not available locally. This echoes the previous findings of Zhang et al. (2011), who reported the reluctance of Developers to use green technologies in projects because of the difficulties associated with finding suppliers for green materials and green appliances. Similarly, Shi et al. (2013) reported limited availability of green professionals as a critical barrier for green practices for both Developers and Contractors in the Chinese construction sector.

Contractors highlighted that due to a lack of local green suppliers, they were forced to import their green materials/equipment from Europe and US, thus resulting in increased project cost and project delay associated with the increased transportation distance. Given that purchase of construction materials/products alone make up 50-80% of the total project cost (Nwoke and Ugwuishiwu, 2011), any currency fluctuation could adversely impact the overall profit, given the fact that they typically work with a tight profit margin of 4 to 6 percent (Lovatt, 2011). Notably, respondents highlighted that importing from distant suppliers defeats the underlying green/environmental objective due to (increased) emissions from transportation. In the words of one Contractor:

“By the time the green materials reach here (UAE) from overseas, they are already brown”.

In the case of Architects/Consultants, because of the lack of local green suppliers, on several occasions they were forced to make specification changes (mostly making compromises on the green aspects) after project start to cope with the increasing project cost and time escalation caused by the uncertainties (such as unexpected delays and cost overruns) associated with green

materials imports, caused by the shortage of local green suppliers. In the case of Suppliers, lack of their local green (raw material) suppliers, such as Bauxite ore suppliers for Aluminium manufacturers, was highlighted as a concern by the Suppliers interviewed, since these raw material suppliers, in general, are few in number.

The survey findings on the shortage of local green suppliers as a barrier of green practices are given in Table 5.10.

Table 5.10 Perceived importance of shortage of local green suppliers by each stakeholder

External green barrier	Developer Mean	Architect/ Consultant Mean	Contractor Mean	Supplier Mean
Shortage of green suppliers	3.4	3.1	3.3	3.3

**Mean is measured on a scale of 1 (no influence) to 5 (extremely high influence)*

As seen in the table, this barrier is moderate and consistent across all stakeholders (mean scores ranged from 3.1 to 3.4). This is in line with the survey findings of Liu et al. (2012), who obtained a mean score of 3.5 (on a comparable 5-point Likert scale) for the shortage of green building professionals in the Chinese construction sector.

From a theoretical standpoint, this can be explained through the lens of resource-dependence theory (Salancik and Pfeffer 1978), where organisations are dependent upon resources provided by outside parties in order to compete (in this case implement green practices). The theory also warrants the need for establishing inter-organizational collaboration and the establishment of formal and semi-formal linkages with other firms (in this case Suppliers) (Ulrich and Barney, 1984) to ensure that strategically critical resources are available (in this case green materials and products/technology).

5.2.1.3 Impact of tight and inflexible stakeholder deadline

Tight and inflexible stakeholder deadline emerged as a significant barrier in the UAE construction sector across stakeholders. This has not been identified previously as a barrier of green practices and hence adds to the novelty of this study. In general, it was evidenced from the interviews that green practices are often compromised because of tight and inflexible stakeholder deadlines. The concern is further heightened by the fact that planning, preparation and execution of green

practices take more time than conventional practices. Their adverse impact on greening can be gauged by the response of one Contractor who said,

“We were given only 24 hours to clear the site upon project completion; we couldn’t segregate the waste and had no option but to send the waste to the landfill.”

To make this worse, in most cases the Developers tight deadlines are accompanied by associated fines (typically charged per day of delay).

However, according to Developers, the tight deadlines are justified from a business standpoint because projects with a shorter completion time and hand over are sold much faster than projects with a longer completion time. For instance, citing the buying habits of consumers/investors, Developers highlighted the main attractiveness of off-plan sales of projects is their faster project completion time. Interestingly, some of the interviewed Developers were found to have a legal clause with buyers in their contract, that they will provide appropriate compensation for the buyer if there is any delay in handing over the project from the mentioned project handover date. Moreover, Developers highlighted the need for faster turnaround time in projects given that demand for buildings in the UAE is outstripping supply. In fact, the deadline set by Developers themselves is adversely affecting their own green efforts. One of the Developers’ senior environmental managers highlighted that he often had to negotiate the deadlines internally with other senior executives and business development managers.

In short, the tight deadline set by Developers is passed on to downstream stakeholders as far as Suppliers. For instance, most Contractors interviewed highlighted that they had no option but to give Subcontractors a similar tight deadline so that they could meet the deadline set by the Developers. Similarly, Subcontractors were found to give Suppliers less time to deliver materials. However, this was relatively less of a barrier for Suppliers given that green materials produced/supplied are generally standard rather than customised for projects.

The survey findings on tight and inflexible deadline as a barrier of green practices are given in Table 5.11.

As seen in the table, the survey findings do conform to the interview findings. Architects/Consultants (M=3.5) and Contractors (M=3.5) emerged as the key stakeholders

impacted by the Developer deadline. While Suppliers (M=2.8) considered this to be less of a barrier as expected, the relatively low score for Developers (M=2.7) could be because they have strong control and flexibility over setting/extending the deadlines of their projects.

Table 5.11 Perceived importance of tight and inflexible stakeholder deadline by each stakeholder

External green barrier	Developer Mean	Architect/ Consultant Mean	Contractor Mean	Supplier Mean
Tight and inflexible stakeholder deadline	2.7	3.5	3.5	2.8

**Mean is measured on a scale of 1 (no influence) to 5 (extremely high influence)*

From a theoretical standpoint, the tight and inflexible stakeholder deadline can be explained from the premise of stakeholder theory and agency theory. Both theories individually and in combination give a clear understanding of this barrier. A stakeholder is ‘any group or individual who can affect or is affected by the achievement of an organisation’s objectives’ (Freeman, 1984). Stakeholder theory suggests that firms produce externalities that affect many parties (stakeholders) which are both internal and external to the respective firm (Freeman, 1984). In this case, externalities produced by the Developer (a key stakeholder) in the form of tight and inflexible deadlines have affected all supply chain stakeholders (external parties) as well as themselves (internal parties).

Agency theory also offers a natural fit to explain the potential conflicts between environmental and financial goals within the Developer firm as seen in this study. An important concept in agency theory (Eisenhardt, 1989) is the ‘self-interested behaviour’ or the behaviour of the agent, in this case, top level executives and business development managers in Developers could operate in their own self-interest rather than in the best interests of the principal firm (to implement green practices). For example, there could be situations where top management often behaves in ways that benefit them financially, and not the environmental team. For example, a CEO may exploit his/her role as an agent by compromising a management practice (in this case GSCM) in order to improve his/her own compensation/profit targets regardless of the actual benefit of the management practice for the company.

5.2.1.4 Impact of lack of stakeholder collaboration

Lack of stakeholder collaboration emerged as a significant barrier to green practices in the UAE construction sector. It was evidenced from the interviews that stakeholders in the UAE construction sector do not effectively engage/collaborate with each other in implementing green practices. As a result, the ability to attain the best possible green outcome on a project is compromised. Some of the reasons identified for this lack of stakeholder collaboration are very intrinsic to the sector. For instance, the Developer-Architect/Consultant and Developer-Contractor relationships are predominantly one-off, with different Architects/Consultants and Contractors being used for different projects. Almost all the interviewed Architects/Consultants and Contractors did not enjoy a long-term or exclusive partnership with Developers. Respondents highlighted the one-off nature of the contracts as a reason for the trust deficit between supply chain stakeholders. Previous studies in construction have also reported a similar lack of trust among supply chain stakeholders as a barrier to green practices (Shi et al., 2013). According to the respondents, this often led to non-sharing of green-related knowledge across stakeholders due to fear that it could be leaked to competitors. Only relevant or minimal details of the project are shared by the Developer with the Architect/Consultant and Contractor. Several interviewees highlighted the struggle they had to go through to get comprehensive project information from the Developer. Contractors highlighted the reluctance of Developers to engage them at the design stage (early stakeholder collaboration) as the main reason for the project variations during build phase leading to waste and re-work. In the words of one interviewee:

“Even though we are the main contractor, we don’t have much say in the design and hence little opportunity in reducing carbon emissions”.

Also, lack of early engagement of stakeholders (including Suppliers) was found to cause project delay due to logistical issues, role conflict from ambiguity in the tender specifications and compatibility issues with environmental systems and other systems in the buildings. Previous studies have stressed the importance of early engagement of stakeholders, including Suppliers at the design stage (Lam et al., 2010; Shi et al., 2013). In fact, Lam et al. (2010) highlighted that ambiguous words or phrases in the tender documentation are often the focal point of disputes

that include green-related issues, and early engagement of stakeholders could, therefore, address these concerns before the projects start.

It was also evidenced from the interviews that the contracts between Developers and Contractors are more stringent and less flexible, lessening the opportunities for Contractors to improvise on green aspects post contract signing/project commencement. For instance, as per one Contractor:

“...we (contractor) was not granted approval to use recycled concrete (green material) that had become available despite scientifically proving its strength and durability to be the same as normal concrete”

However, Developers were not the only source of the problem. The Architects/Consultants were also found to have a reluctance to share all green design related ideas with the Developers to avoid them being appropriated for future projects. Similarly, it was observed that Architects/Consultants were reluctant to share full information with Contractors too on important aspects such as constructability, feasibility and environmental impact (from fear that they could take over their design role in future projects), leading to Contractors not being able to plan the green construction activities effectively. In short, the overall efficiency and effectiveness of green practices implementation across the supply chain is compromised.

For Suppliers, this was found to be less of a barrier because most of them follow industry standards and global best practices for green material/product development and usually supply standard green products and often there is less room for project specific customised green products, which is typically expected from a stakeholder engagement/collaboration. Still, a small number of Suppliers highlighted the possibility of offering customised green products as per the requirement of projects, provided they are involved from the design or pre-design stage and if adequate time for order fulfilment is provided. Suppliers also highlighted the lack of stakeholder collaboration as the reason for the lack of collaborative research and development between stakeholders, which is a common practice in other manufacturing sectors. The survey findings on lack of stakeholder collaboration as a barrier of green practices are given in Table 5.12.

Table 5.12 Perceived importance of tight and inflexible stakeholder deadline by each stakeholder

External green barrier	Developer Mean	Architect/ Consultant Mean	Contractor Mean	Supplier Mean
Lack of stakeholder collaboration	2.7	3.4	3.5	2.8

**Mean is measured on a scale of 1 (no influence) to 5 (extremely high influence)*

The survey findings to a considerable extent conform to the interview findings. The relatively high score for Architects/Consultants (M=3.4) and Contractors (M=3.5) is expected given the lack of collaboration from Developers. For Developers, this is less of a barrier (M=2.7) because they have the power to decide the nature and extent of collaboration with other stakeholders given their superior position in the supply chain hierarchy. For Suppliers, the relatively low mean score (M=2.8) could be due to the standardised products they supply, which requires less collaboration.

From a theoretical perspective, lack of stakeholder collaboration can also be explained using stakeholder theory. The externalities produced by a stakeholder (in this case is the lack of willingness to collaborate), has affected other stakeholders in the supply chain (external) as well as themselves (internal). The latter (internal externalities) is caused because if a stakeholder shows reluctance to collaborate with others stakeholders, other stakeholders may reciprocate the same reluctance.

5.2.2 Assessing internal barriers

The two main internal green barriers identified from the interviews are the high cost of implementation and lack of knowledge and awareness. The following subsections will discuss in sequence these internal green barriers including their perceived importance/relevance.

5.2.2.1 Impact of high cost of implementation

The high cost of implementation being a barrier to green practices was acknowledged by all the stakeholders interviewed. This is categorised as an internal barrier because the perceived importance/relevance of this barrier is contingent on the financial and human resources of a firm. For example, a firm with several green professionals and a high capital and operational budget may consider this less of a barrier than firms with low capital and fewer personnel.

According to Developers, green projects are on average 10 to 20% more expensive than conventional projects. The response from one of the interviewees was therefore not surprising:

“we developers need to fetch a higher price for green buildings, otherwise the benefits would largely be enjoyed by the end user.”

The reasons identified include the high material/equipment costs, architectural and consulting fees, construction costs (contractors bid) and green certification costs such as LEED (if applicable). This echoes the previous findings in the construction literature that highlight financial constraints due to the increased architectural and engineering design time and modelling costs as a major deterrent for Developers from pursuing green projects (Zhang et al., 2011). Also, a secondary search in the UAE construction sector revealed that green materials are 15-20% more expensive than conventional materials (Future Build, 2016). Moreover, while discussing consumer pressure (green driver), the study highlighted the lack of willingness of end-consumers in the UAE to pay a premium for green buildings. So, high investment coupled with the lack of premium for green building is a major deterrent for Developers to work on environmental projects.

Architects/Consultants also highlighted high investment cost as a deterrent in developing green-related in-house capabilities. For example, Architects/Consultants highlighted the challenges associated with the high cost of green design tools and energy modelling simulation software and the high operational cost associated with hiring and maintaining LEED or related green certified professionals in the payrolls. Also, they highlighted the high cost due to the relatively longer time required for green building design vis-à-vis conventional design because of the complexities involved in it. In fact, two of the Architects/Consultants highlighted the challenge of designing green buildings without compromising on the aesthetics of the buildings such as cladding, glass façade and integration of solar panels. Also, as stated before, respondents highlighted the need for more professionals to work on green design than a conventional design, which further increases cost.

In the case of Contractors, respondents highlighted the high cost associated with the implementation of EMS and ISO 14001 certification/re-certification, employee environmental training and purchase of automation equipment such as concrete mixers and spreaders. While

for large contractors, this may be a small proportion of their annual turnover, for small firms, the investment could mean a considerable portion of their revenues and could impact operational cash flow, which in extreme cases could lead to bankruptcy. One of the interviewees from a small Contracting firm commented:

“...government regulation should also take into account the financial capability of firms, forced implementation of green practices such as EMS and ISO 14001 could well mean that we go out of business”

Interviewed Suppliers were also very critical of the high implementation cost. For instance, most of the interviewees highlighted that their green manufacturing equipment/technology, imported from countries such as Germany and France, are very expensive upfront as well as to maintain (requires expensive annual maintenance contract with equipment manufacturers). In addition, respondents stressed that purchase of green input materials (extracted in a sustainable way and free from impurities) is more expensive than conventional equivalents. Respondents also pointed out the significant R&D investments needed to develop green materials.

The survey findings on the perceived importance/relevance of this barrier are given in Table 5.13.

Table 5.13 Perceived importance of high cost of implementation by each stakeholder

Internal barrier	Developer Mean	Architect/ Consultant Mean	Contractor Mean	Supplier Mean
High cost of implementation	3.6	3.5	3.7	4.3

**Mean is measured on a scale of 1 (no influence) to 5 (extremely high influence)*

The survey findings demonstrate that the barrier is moderate but consistent across all stakeholders (mean range of 3.5 -3.7) except for Suppliers (M=4.3). However, comparing it with the findings in the construction literature, the perceived impact of these barriers (except for Suppliers) is relatively less of concern for the UAE construction sector. For example, Zhang et al. (2011), obtained a mean score of 4.3 on a comparable 5-point scale for high cost of implementation (green materials and appliances) in the Chinese construction sector. For Suppliers, this could well be due to the reasons discussed above. However, this is still a concern that needs to be addressed at the sector level.

From a theoretical standpoint, this high cost of implementation as a barrier of green practices can be explained from a resource-based view. The firm's ability to overcome this barrier is contingent on their organisational resources, defined as all assets, capabilities, organisational processes, firm attributes, information and knowledge possessed by a respective firm (Barney, 1991). Therefore, the more resources a firm has, the lower the likelihood that this barrier will have an impact.

5.2.2.2 Impact of lack of knowledge and awareness

Lack of knowledge and awareness being a barrier to green practices was acknowledged by most of the stakeholders interviewed. For Developers, this barrier was more profound in areas pertaining to performance measurement/monitoring. They also acknowledged the lack of knowledge and awareness of their (or outsourced) facilities management staff in managing green systems and technology effectively during the operational phase (post-occupancy). For example, one of the interviewed Developers highlighted that their LEED certified building performed below par because of the lack of knowledge of the facility team in maintaining/operating green systems. For Architects/Consultants, this was found to be less of a barrier, as most of the designers and planning engineers in the interviewed firms have LEED or other green related certification. In most cases, in addition to in-house training, employees were encouraged to attend training programs and earn green certifications, so that they remain up to date with the latest green-related knowledge.

For Contractors, the main concern was the lack of knowledge and awareness of onsite construction workers. This was not surprising given that all the interviewed firms use mainly unskilled workers from South-Asian countries for onsite construction. The other concern highlighted by Contractors is the varying degree of knowledge and awareness of individual project managers. Given the importance of the role of project managers, lack of knowledge and awareness of individual project managers can significantly undermine the greening efforts at the project level.

For Suppliers too, this was found to be less of a barrier. Given that most of the Suppliers interviewed are involved in green-related R&D, knowledge is kept up-to-date (through training

programs) to facilitate research & development of new green materials. Moreover, Suppliers, because of their exports, are knowledgeable about multiple export country government regulations as well as several international green standards and certifications.

The survey findings on the lack of knowledge and awareness are given in Table 5.14

Table 5.14 Perceived importance of lack of knowledge and awareness by each stakeholder ..

Internal barrier	Developer Mean	Architect/ Consultant Mean	Contractor Mean	Supplier Mean
Lack of knowledge and awareness	3.6	2.9	3.4	3.0

**Mean is measured on a scale of 1 (no influence) to 5 (extremely high influence)*

The survey findings to some extent conform with the interview findings. However, lack of knowledge and awareness of Developers being the highest of all the stakeholders is a major concern due to their role and position in the supply chain. This echoes some of the previous findings in the construction literature. For instance, a survey conducted by Abidin (2010) found knowledge and awareness of Developers in Malaysia to be low. Similarly, the results are comparable to the mean score of 3.4 (on similar 5-point Likert scale) obtained by Zhang et al. (2011). Further, Shi et al. (2013) reported lack of knowledge of green technology and the durability of green materials as a significant barrier preventing the construction sector from implementing green practices.

From a theoretical stance, this barrier can be explained from the premises of knowledge-based view. As mentioned earlier, knowledge-based view considers knowledge as the most critical asset of the firm. Therefore, improving knowledge of firms on GSCM aspects is key to overcoming this barrier. In fact, efforts are already underway to increase the knowledge and awareness levels of stakeholders in the UAE. This includes green/sustainability conferences, workshops, and seminars, mainly organised by the UAE government in partnership with leading construction firms. Still, there is a long way to go to improve the knowledge and awareness levels of all concerned parties, as evidenced from the interview and survey findings.

5.3 Summary of findings

This section summarises the overall findings by construct, namely external drivers, internal drivers, external barriers and internal barriers. This high-level summary is significant as it reveals some important observations/patterns at the strategic level. Table 5.15 summarises the findings at the construct level. Although the causal relationships between green drivers and barriers on green practices will be investigated later in Chapter 7, the descriptive statistics are used to make an overall sense of the importance/relevance attached to these drivers and barriers by stakeholders.

Table 5.15 Perceived importance/relevance of green drivers and barriers at the construct level

Stakeholder	Developer	Architect/ Consultant	Contractor	Supplier
Construct	Construct Mean (SD)	Construct Mean (SD)	Construct Mean (SD)	Construct Mean (SD)
External drivers	2.8 (1.1)	3.1 (0.9)	3.2 (1.2)	2.9 (0.7)
Internal drivers	2.6 (1.4)	3.6 (1.1)	3.5 (1.2)	4.3 (0.7)
External barriers	2.9 (0.8)	3.2 (1.1)	3.4 (1.0)	3.0 (0.9)
Internal barriers	3.6 (0.8)	3.2 (1.0)	3.6 (0.9)	3.7 (1.0)

Construct mean (Scale 1-5) - Average of the individual mean values of items representing that construct

Construct SD (Scale 1-5) - Average of the individual standard deviation of items representing that construct

As seen in the table, all stakeholders, except Developers, are more motivated internally than externally 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, the perceived relevance/importance of both external (M=2.8) and internal pressures (M=2.6) by Developers are relatively lower than other stakeholders. Moreover, the high standard deviation (SD>1) for external and internal drivers for Developers demonstrates considerable variation in the way firms perceive these pressures. While there is the 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 4.3. In terms of barriers, Developers and Suppliers perceived

internal barriers more than external, while in the case of Architects/Consultants and Contractors, the perceived external and internal barriers emerged to be more or less the same.

Overall, there is significant scope to address and minimise/eliminate both external and internal barriers for the construction sector.

To summarise, this chapter addresses the second research question in this thesis. The chapter identifies the various green drivers and barriers of green practices implementation and the perceived importance/relevance of these drivers and barriers for each stakeholder. A comprehensive, theory enabled understanding of green drivers and barriers in such detail has not been executed previously in the construction sector and therefore constitutes the novelty of this chapter. This understanding is expected to guide practitioners and policymakers on ways to leverage these drivers and minimise/eliminate the barriers to achieving extensive supply chain wide implementation of green practices.

Chapter 6 – Assessing the Performance Impact of Green Practices

While in chapter 4, the core and facilitating practices were discussed, including their extents of implementation, in line with our research question (RQ3), the objective of this chapter is to develop a comprehensive understanding of the green performance impact/benefits of green practices implementation, namely environmental, cost/economic and organisational performance in the construction sector. As stated previously, to capture/assess green performance, it is important to first have relevant performance measures in place. This chapter, therefore, will first discuss the relevant green performance measures for each stakeholder based on the interview and literature findings. The chapter then discusses the green performance improvement for each stakeholder based on the results of the country-wide survey.

From a practitioners' perspective, the potential contribution of this chapter is twofold. First, the findings related to performance measures could be used to operationalise important performance measures in their respective firms. Secondly, the survey findings on the actual green performance benefits at the sector level, if positive, may provide impetus and business case for construction firms to implement green practices.

Finally, in this chapter, both the application of performance measures and the extent of performance improvement will be discussed in the light of appropriate management/organisational theories in order to develop a broader understanding and to link it with the larger body of GSCM literature. Here also, any effects of firm size and firm ownership on the performance aspects will be discussed separately in Chapter 10. Furthermore, the causal relationships between green practices and green performance will be discussed separately in Chapter 8.

The following sections will discuss in sequence the relevant green performance measures (environmental, cost/economic and organisational) and their extent of improvement for each stakeholder in the UAE construction sector.

6.1 Environmental performance impact

Environmental performance refers to the ability of the firm or sector to minimise the adverse impact it has on the natural environment. In the following sub-section, the relevant

environmental performance measures identified from the interviews for each stakeholder are discussed, followed by a discussion on the extent of improvement based on the survey results.

Developers: It was evident from the interviews that the environmental performance measures used by Developers include measures to capture the environmental performance during the construction/build phase and the operational phase of the building.

The two key operational phase measures identified include reduction in water consumption and reduction in energy consumption. According to respondents, the high importance/relevance attached to these measures is mainly because capturing water and energy consumption of buildings is mandated by regulatory bodies (in Dubai and Abu Dhabi). As per the regulation, Developers are required to install meters and submeters to measure and record electricity and water consumption of the facility as a whole as well as any major energy and water consuming sub-systems (chiller plant, heating, ventilation and air conditioning) in the building separately.

In the construction phase, most Developers were found to monitor environmental accidents, though these were captured under the category of 'general accidents' as part of the health and safety regulations. Also, few Developers were found to monitor the total material consumption and waste generation per unit area constructed in their projects as part of their efforts to minimise their environmental impact. However, for both these measures, Developers have to rely heavily on the main Contractor to supply the data. Regardless, one of the interviewed Developers, who achieved a reduction in materials and waste in their project, has used it as a marketing tool to showcase their success with environmental initiatives and consequently gained significant media coverage. However, only a few Developers, and only in select green projects, were found to monitor GHG emissions and hazardous material usage. Still, an important observation from the interview is that the projects that were initiated with the intention of achieving LEED or similar green certification were found to monitor all the above-discussed aspects as part of their certification requirements. Interestingly, despite being capable, some Developers were found not measuring the environmental aspects for non-LEED projects. When probed, they stressed that monitoring and tracking performance measures are costly and time-

consuming and therefore will not be performed unless they get full value out of them (in the form of LEED certification or reputational boost through media coverage).

Overall, the use of environmental performance measures by Developers can be related to the previous findings in the construction sector literature. For instance, Tam et al. (2006) reported a reduction in water, energy and materials as important environmental performance measures for Developers in the Hong Kong construction sector. Similarly, among others, Chen et al. (2010) reported a reduction in energy and material consumption as two important environmental performance measures for Developers in the US construction sector. In addition, interviews also acknowledged the importance/relevance of the project based environmental performance measures reported in the literature, such as reduction in: water, energy, air emissions, waste, total materials, hazardous materials and environmental accidents (Adetunji et al., 2008; Fernández-Sánchez and Rodríguez-López, 2010; Gangolells et al., 2009).

Architects/Consultants: In the case of Architects/Consultants, the use of environmental performance measures like the ones mentioned above were mostly found in prestigious green projects where they played a central role in improving the environmental performance. They were found to rely mainly on the Developer to supply the relevant operational environmental data and the Contractor for the construction/build phase data. Also, some of the Architects/Consultants were found to estimate/simulate the life-cycle CO₂ emission savings for some of their green projects. It was evident from the interviews that the objective of capturing environmental performance data was mainly to show improvements for marketing purposes. For Architects/Consultants, previous studies have recommended the use of environmental performance measures similar to that of Developers (Tam et al., 2006; Chen et al., 2010).

Contractors: The use of environmental performance measures were found to vary across firms and projects. While reporting some of the measures are mandated by the government (such as waste statistics and environmental accidents) and Developers (such as material consumption and waste generated), Contractors themselves were found to monitor and report air emissions, use of hazardous materials, material, energy and water consumption, waste landfilled and number of environmental accidents, though the exact measures were found to vary. These measures are similar to the project based environmental performance measures reported in the literature

(Adetunji et al., 2008; Fernández-Sánchez and Rodríguez-López, 2010; Gangolells et al., 2009). Further, several Contractors interviewed were found to publish environmental performance as part of their firms' annual report as well as in their departmental publications and internal newsletters.

Suppliers: The interview findings demonstrate that Suppliers are keen on collecting and reporting environmental performance measures. For instance, most of the Suppliers interviewed have formalised measures for reporting environmental performance. Also, it was observed that for a small number of the interviewed Suppliers, environmental performance is one of their key performance indicators and is tracked and reported on a quarterly basis. Moreover, in addition to the environmental performance being reported in the annual reports (as seen in many Suppliers), a few Suppliers were also found to publish comprehensive sustainability reports annually with open access to the public. The environmental performance measures of Suppliers identified from the interviews and secondary firm data include reduction in air emissions; reduction in the use of hazardous materials; reduction in material, energy and water consumption; reduction in landfill waste; and reduction in the number of environmental accidents. These are similar to the environmental performance measures reported in the general manufacturing sector (Zhu et al., 2007b; Green et al., 2012). Also, product/equipment Suppliers such as HVAC Suppliers were found to obtain the building commissioning test reports relevant to them as well as the operational performance data from Developers to benchmark their actual performance with theoretical performance. In general, Suppliers were found to use more formalised performance measures compared to other stakeholders.

Overall (except Suppliers), it could still be generalised that the use of formal environmental measures in the UAE construction sector is still in its infancy. Also, a general lack of consistency in the reported measures was seen across all stakeholders. Furthermore, the frequency of reporting varied from no reporting to ad-hoc/one-off reporting to quarterly, half yearly and annual reporting. Finally, the stringency of reporting ranged from a high level of transparent externally audited reporting to non-audited self-reporting.

From a theoretical standpoint, this limited and/or inconsistent use of performance measures can be understood using legitimacy theory (O'Donovan, 2002). Legitimacy is a generalised perception

or assumption that the actions of an entity are desirable, proper or appropriate within the socially constructed system of norms, values, beliefs and definitions. Based on this understanding, companies seek to gain, maintain or repair their legitimacy by using environmental reporting measures. This is because environmental disclosure is often requested by a number of parties, such as governments and stakeholders. Also, legitimacy makes firms standardise their reporting measures due to particular demands, especially from the government where they are operating (Geijer and Stureson, 2013). However, at present in the UAE, there is no stringent legitimacy requirement from the government on firms to report these measures, except for water and energy consumption of buildings in the operational phase. Nevertheless, it was evident from the interviews that voluntary reporting can significantly increase the legitimacy of the firms among stakeholders, investors and buyers, while also allowing firms to secure new projects successfully. Overall, after a comprehensive analysis of the interview findings, literature findings and secondary firm data, and that too across all stakeholders, the relevant environmental performance measures for the construction sector that can be applied across all stakeholders are as follows:

- Reduction in environmental accidents
- Reduction in greenhouse gas emissions
- Reduction in water consumption
- Reduction in energy consumption
- Reduction in material consumption
- Reduction in waste generated

The knowledge of these measures, which are easy to comprehend and capture, is expected to enhance the use of environmental performance measures across all stakeholders in the UAE construction sector and in general.

Next, the actual improvement in environmental performance from green practices implementation are discussed.

Given the limited use of measures and reliable environmental performance data in the sector, this study will try to capture/assess the performance improvement using the results from the

country-wide survey. The evidence from the literature also shows that surveys have been the most preferred method in the literature to capture performance (Malviya and Kant, 2015).

The survey findings on environmental performance are given in Table 6.1

Table 6.1 Environmental performance impact for each stakeholder

Individual environmental performance factors	Developer Mean	Architect/Consultant Mean	Contractor Mean	Supplier Mean
Reduction in environmental accidents	3.2	3.5	3.9	4.7
Reduction in greenhouse gas emissions	3.1	3.6	3.6	4.2
Reduction in water consumption	3.2	3.7	3.6	4.3
Reduction in energy consumption	3.3	3.7	3.7	4.5
Reduction in landfill waste	3.1	3.5	3.6	4.0
Reduction in material use	2.8	3.2	3.5	4.0

**Mean is measured on a scale of 1 (no improvement) to 5 (very high improvement)*

As seen in the table, the survey results (on a scale of 1 – 5) show that environmental performance among stakeholders is highest for Suppliers with the mean score for each item/factor greater than 4.0. This was not surprising, given that there were multiple instances of high Supplier performance (environmental) during the interviews. For example, one aluminium Supplier interviewed was found to have reduced its chlorofluorocarbon (CFC) emissions by 50% and waste generation by 10% within two years from implementing green practices. Similarly, a glass manufacturer was found to have reduced its CFC emissions by 60% and energy consumption by 30%. On the contrary, each aspect of environmental performance emerged as the lowest for Developers, with a mean score range of 2.8 to 3.3. Again, this was not surprising given their laggardness in green practices implementation (as seen in Chapter 4) and general laggardness in capturing and reporting performance measures. For Architects/Consultants and Contractors, as seen in the table, the improvement in environmental performance is moderate with mean scores ranging from 3.2 to 3.7 for Architects/Consultants and 3.5 to 3.9 for Contractors. This could well be due to the variation in the performance of firms of different sizes and ownership, which will be explored further in Chapter 10. In general, all stakeholders, except Suppliers, have plenty of opportunities to improve their environmental performance.

6.2 Economic/cost performance impact

Economic/cost performance refers to the ability of the firm or sector to reduce costs (in this case, through implementing green practices). As stated before, from a business perspective, this is an important performance aspect to justify investment in green practices, especially from a short-term perspective. In the following sub-section, the relevant economic/cost performance measures identified from the interviews for each stakeholder are discussed, followed by discussions on the extent of improvement in performance based on the survey findings.

Developers: As highlighted earlier, in a construction project, cost reduction is possible during the construction/build phase and the operational phase. However, since the majority of the Developers sell-off their projects instead of leasing them to tenants, operational savings such as water and energy consumption costs are not relevant to them as they are enjoyed solely by the end-users. The two commonly used construction/build phase measures identified from the interviews are reduction in overall material costs and reduction in environmental-related fines such as regulatory non-compliance fines and environmental accidents fines. According to the respondents, it makes sense to use these measures because in any case, they are monitoring the total material used per square feet of every project as well as keeping track of environmental accidents as part of monitoring environmental performance. Respondents stressed the importance of keeping track of material expenses in green projects, as the information can be used to leverage a lower tender bid from Contractors in future green projects. Previous studies have also reported similar economic/cost performance measures for Developers (Chen et al., 2010).

Architects/Consultants: It was evident from the interviews that for Architects/Consultants, economic/cost performance is not relevant since they are not directly involved in any financial aspect of the project. For example, in the design/tender stage, financial aspects are handled by the Developers, whereas Architects/Consultants are mainly responsible for the technical aspects of the design and tender. This can be summarised in the word of one interviewee:

“..... we don't have any cost benefits from helping other stakeholders achieve cost benefits from environmental practices”

Contractors: It was evident from the interviews that Contractors, compared to other stakeholders, were active in measuring economic/cost performance. This was because most of the respondents have recognised the significant potential of green practices in reducing project costs. Some of the common economic/cost aspects identified from the qualitative investigation include reduction in material costs, reduction in energy expenses; reduction in water expenses; reduction in waste management expenses; and reduction in environmental fines and penalties. This was not surprising given that cost saving was highlighted as one of the internal drivers or motivating factors to implement green practices in the first place (refer chapter 5, section 5.1.2.3). Also, the economic/cost performance measures identified can be compared with the previous measures identified in the construction literature such as material costs (Jaillon et al., 2009; Chen et al., 2010), waste management costs (Begum et al., 2007) and overall construction costs (Zhang et al., 2011) as well as with the measures used in generic literature in other sectors (Zhu et al., 2007b; Green et al., 2012).

Suppliers: Suppliers were also found to use economic/cost performance measures to capture the cost benefits of green practices. Though the exact measures used have varied across firms, these measures have broadly covered benefits related to material costs, water and energy costs, and waste management costs. This is also in line with the measures used in the previous studies for manufacturing sector (Zhu and Sarkis, 2004; Green et al., 2012). Again, this was not surprising, given that 'reduce costs' was highlighted as one of the important drivers for Suppliers to implement green practices (refer chapter 5, section 5.1.2.3).

Overall, still, compared to the use of environmental performance measures, the use of economic/cost performance measures was found to be limited in the construction sector. Also, a similar lack of consistency in the reported measures was seen across all stakeholders.

Regardless, after careful review and analysis of interview findings, literature findings and secondary firm data, and that too across all stakeholders, the relevant economic/cost performance measures identified for the construction sector are as follows:

- Reduction in energy expenses
- Reduction in water expenses

- Reduction in material expenses
- Reduction in expenses related to waste management
- Reduction in cost associated with environmental-related fines/penalties

The results from the county-wide survey are given in Table 6.2.

Table 6.2 Economic/cost performance impact for each stakeholder

Individual economic/cost performance factors	Developer Mean	Architect/Consultant Mean	Contractor Mean	Supplier Mean
Reduction in material expenses	1.30	-	3.26	3.02
Reduction in water expenses	-	-	3.39	3.67
Reduction in energy expenses	-	-	3.42	3.83
Reduction in waste management expenses	-	-	3.37	3.89
Reduction in cost associated with environmental fines/penalties	2.54	-	3.50	3.66

**Mean is measured on a scale of 1 (no improvement) to 5 (very high improvement); '-' indicate the item is not applicable for the stakeholder*

As seen in the table, the meagre mean score of 1.30 for reduction in material expenses for Developers shows that they are unable to reduce the material expenses despite some evidence of them reducing the overall material usage in green projects (mean score of 2.78, reported in Table 6.1). This high overall material cost in green projects despite slightly lower (overall) material usage points to the high price of green materials vis-à-vis conventional materials. In fact, our subsequent secondary search supports this finding as it shows green materials are 15-20% more expensive than conventional materials (Future Build, 2016). Previous studies have also highlighted the high cost of green materials vis-à-vis conventional materials (Jaillon et al., 2009; Zhang et al., 2011). However, there is some evidence of reduction in the cost associated with reduction in environmental fines/penalties (M=2.54).

On the contrary, Contractors and Suppliers were able to reduce costs, though moderately. This was not surprising given that one of the Contractors interviewed was able to save £0.15 million from a single project through green construction practices. This is a prime example and shows the potential opportunities for Contractors to achieve economic/cost performance in projects. Similarly, Suppliers interviewed were also found to improve their cost performance from green

practices. For most of them, energy costs had reduced by 8%-40% and water costs by 5%-10% as result of implementing green practices.

6.3 Organisational performance impact

Organisational performance refers to the ability of the firm or sector to improve its financial and marketing performance. While all firms report organisational performance (as result of various activities) such as increase in sales, sales price, profits, market share etc., the objective here is to understand the improvement in organisational performance from green practices separately. For example, it would be useful to know the “average sales price per unit area of green buildings” vis-à-vis “average sales price per unit area of all buildings”.

Along with economic/cost performance, this is also an important measure from a business perspective to justify investments in green practices, especially from a long-term perspective. Moreover, given the fact that two out of the four internal drivers identified in this study (enhance reputation/brand image and enter foreign markets) are directly linked to financial and marketing performance, the use of organisational performance measures is critical for firms to make sense of their green investments.

Unfortunately, despite the importance of knowing the organisational performance benefits from green practices, very few firms (across all stakeholders) were identified as having made efforts to assess the organisational performance benefits of green practices. However, when probed, most stakeholders acknowledged the importance of using the following (generic/ standard) performance measures for assessing organisational performance benefits:

- Increase in sales
- Increase in sales price
- Increase in market share
- Increase in return on investment
- Increase in profits

These measures are similar to the measures used in the other sectors, such as manufacturing, to capture the organisational performance benefits of green practices (Green et al., 2012). The

advantage here, unlike other measures, is that practitioners could use the same standard/generic organisational performance measures that they are familiar with in their respective firms.

To understand the actual improvement in organisational performance, like previous studies in other sectors such as manufacturing (Green et al., 2012), this study had to rely on the survey data by explicitly asking the respondents the “improvement in organisational performance from implementing green practices”.

The survey findings on the organisational performance improvement from green practices are given in Table 6.3.

Table 6.3 Organizational performance impact for each stakeholder

Individual organizational performance impact	Developer Mean	Architect/Consultant Mean	Contractor Mean	Supplier Mean
Increase in sales	2.89	3.40	3.24	3.61
Increase in sales price	2.56	3.37	3.30	3.50
Increase in market share	2.87	3.51	3.27	3.50
Increase in return on investment	2.78	3.45	3.25	3.16
Increase in profits	3.11	3.31	3.17	2.83

**Mean is measured on a scale of 1 (no improvement) to 5 (very high improvement)*

The results, as seen in the table, show that implementation of green practices has led to improvement in organisational performance (to varying extents) across all stakeholders. The insights from the interviews, to a certain degree, can reason the ‘why’ and ‘how’ aspect of the above survey results for each stakeholder.

Developers: The interviewees acknowledged that implementing green practices has not only increased the attractiveness of a particular project but also increased the attractiveness of the firm as a whole. For example, Zhang et al. (2011) reported that Developers in China sold their green projects much faster and managed to generate good profits because they were well received in the market and buyers were willing to pay a higher price. Respondents were also optimistic about achieving high organisational performance in the near future as more and more consumers/end-users and investors are becoming aware of the benefits of green buildings. In

addition, green practices have helped Developers meet the green regulation of foreign governments, enabling them to expand to foreign markets, thereby increasing market share.

Architects/Consultants: According to respondents, because of green practices, they were able to easily pre-qualify for participation in the tender by meeting the environmental criteria and subsequently managed to win more projects. Moreover, interviewed Architects/Consultants highlighted that they were able to charge a premium for their services from Developers. Also, there was evidence of green practices increasing the attractiveness of Architects/Consultants to the extent that in some cases Developers were seen approaching them to be their Architects/Consultants. Further, green practices have helped them participate and win more global tenders.

Contractors: Like Architects/Consultants, interviewed Contractors were also found to achieve organisational performance benefit from the green practices. For instance, implementing green practices such as EMS and ISO 14001 has enabled them to pre-qualify for participation in more tenders. According to respondents, competition in green projects is relatively less vis-à-vis conventional projects. This has also allowed them to achieve profits in the range of 5% to 10% compared to 2% to 5% in conventional projects. In addition to the higher fee realisation for green projects, the cost reduction from onsite green practices has also contributed to increased profits. In addition, respondents highlighted that despite the higher upfront costs of green-related equipment, the return on investment is also higher. Moreover, green practices implementation has enabled them to win projects outside the UAE, thereby increasing market share.

Suppliers: In the case of Suppliers, respondents highlighted that green practices, such as green design and green-related research and development, have helped them create a new 'green product' segment or increase their existing green product portfolio. Moreover, innovative green products have helped them catch the attention of Architects/Consultants, leading to their inclusion in tender specifications as one of the preferred Suppliers. This has significantly increased their chances of winning more sales orders. Moreover, given the limited number of green Suppliers in the UAE, they were also able to charge a premium for green products.

Although there is significant scope for improvement in organisational performance as evident from Table 6.3, in particular for Developers who are lagging others, the results are still encouraging for the sector and could provide the impetus for firms to implement green practices to improve their organisational performance.

While this study explained environmental performance from a legitimacy theory perspective, economic/cost performance and organisational performance is better explained using transaction cost economics theory (both internal and external) (Williamson, 1981). The explanation for internal transaction cost economics is similar to the discussion in Chapter 5, section 5.1.2.3. That is, at the macro level, any investment in green practices can be seen as an internal transaction for stakeholders, with the transaction cost benefits being mainly improvement in economic/cost performance and organisational performance, though improvement in environmental performance can also be seen as a transaction cost benefit.

Similarly, improvement in economic/cost and organisational performance is also contingent on the external transactions between stakeholders. For example, the high selling price for Developer would depend on the transaction between Developer and buyer/end-user. Similarly, for Architects/Consultants, winning projects with high-profit margin could also depend on how effectively they manage the transaction with the Developer. Transaction cost economics (external) focuses on how much effort and cost is required for the two entities, the buyer and the seller, to engage in a relationship that will allow for effective completion of a transaction (Williamson, 1981). For example, for Architects/Consultants participating in the tender for a green project, there is scope for them to charge a premium for their services from the Developer given that the UAE is a relatively new market for green projects and therefore there is less competition. On the other hand, it would be more difficult if Architects/Consultants were trying to sell the green design/concept to Developers who are not interested in green projects as they would have to convince the Developer of the potential benefits from the project. Overall, it can be generalised that transaction cost requirements are less stringent or relaxed when both parties involved in the transaction demonstrate an environmental commitment.

6.4 Summary of findings

This section summarises the overall survey finding on environmental, cost/economic and organisational performance for each stakeholder. Again, this macro-level summary is important as it reveals some important observations/patterns at the strategic level. Table 6.4 summarises the survey findings related to performance.

Table 6.4 Green performance impact at construct level

Stakeholder	Developer	Architect/ Consultant	Contractor	Supplier
Construct	Construct Mean (SD)	Construct Mean (SD)	Construct Mean (SD)	Construct Mean (SD)
Environmental performance	3.2 (1.1)	3.6 (1.1)	3.7 (0.9)	4.3 (0.8)
Economic/cost performance	1.9 (1.1)	-	3.4 (1.0)	3.6 (1.0)
Organizational performance	2.8 (0.9)	3.4 (0.8)	3.3 (1.0)	3.3 (1.1)

Construct mean (Scale 1-5) - Average of the individual mean values of items representing that construct

Construct SD (Scale 1-5) - Average of the individual standard deviation of items representing that construct

As seen in the table, all three aspects of performance (environmental, cost/economic, and organisational) were lower for Developers in comparison to other stakeholders; more so with regards to economic performance with a mean score as low as 1.9. This is a serious concern for the UAE construction sector from a greening perspective, given that Developers initiate green projects. The improvement in environmental and economic/cost performance was found to be the highest for Suppliers (mean scores of 4.3 and 3.6, respectively), whereas the improvement in organizational performance emerged to be slightly higher for Architects/Consultants (mean score of 3.4) compared to Contractors (mean score of 3.3) and Suppliers (mean score of 3.3).

Still, except for economic/cost performance for Developers, the construct level results show that green performance, in general, is comparable to findings from other sectors and developed countries. For example, an empirical survey-based investigation conducted by Green et al. (2012) in the US manufacturing sector, using measures and scales comparable to the ones used in this study, shows that the mean score for environmental performance is 3.5, economic/cost performance is 3.3, and organisational performance is 3.4. In fact, the performance of Suppliers in the UAE exceeds the performance of US manufacturing firms in all three dimensions.

The other important aspect is the fact that a win-win scenario (that is improving all three aspects of performance at the same time) was observed for all stakeholders except Developers. In the case of Developers, a trade-off was seen between environmental performance and economic/cost performance. This shows that different scenarios are possible depending on the green goals of the stakeholder. This can be explained using strategic choice theory. A stakeholder can choose strategically to decide on improving all three performance aspects or focus on one or two performance aspects. For example, Developers may still go for green projects to improve environmental and organisational performance knowing that they will not do well in economic/cost performance.

To summarise, this chapter addresses the third research question (RQ3) in this thesis. The chapter identified relevant/important green performance measures for capturing environmental, economic/cost and organisational performance as well as their extent of improvement. Since firms cannot effectively manage what they do not measure, the insights on relevant performance measures could be useful for practitioners to operationalise performance measures to capture the effectiveness of their green practices implementation. Moreover, the significant “win-win” opportunities identified in the study should provide the impetus for firms to implement green practices in the construction sector.

Overall, a comprehensive, theory enabled understanding of all three green performance aspects has not been undertaken previously in the construction sector and therefore adds to the novelty of this thesis.

Chapter 7- Impact of Green Drivers and Barriers on Green Practices

Chapter 4 and chapter 5 discussed green drivers, green barriers and green practices including their perceived importance/relevance (in the case of drivers and barriers) and extent of implementation (in the case of green practices). While these findings are useful in their own right, in line with our research question RQ4, the objective of this chapter is to develop a comprehensive understanding of the causal relationships between green drivers, barriers, and practices for each stakeholder, both at the strategic level and at the operational/implementation level to further comprehend the scope of both problems and the opportunities associated with GSCM. The underlying logic or need for this understanding/assessment is simple and can be explained from a force-field theoretical perspective (Lewin, 1951), i.e. the implementation of green practices would depend on the opposing forces/pressures of green drivers and green barriers; therefore, for the extensive implementation of green practices, the driving forces (from green drivers) must exceed the restraining forces (from green barriers).

As stated previously, for practitioners and policymakers, looking at the impact of green drivers and barriers on green practices together is critical for effectively managing the antecedents (i.e. leveraging drivers and minimising/eliminating barriers) for firm-wide/sector-wide efficient and effective implementation of green practices. Furthermore, relevant management/organisational theories (wherever applicable) will be used in this chapter to render a deeper, broader and more simplified understanding of the relationships.

The following section will discuss the relationships (as per the research questions and proposed hypotheses), both at the strategic level and at the operational/implementation level. The reason for having these assessments at two levels is simple but very important. Metaphorically, strategic assessment would be similar to the school principal or the child's parents interest in knowing the factors affecting the 'overall/combined' IQ of the student (in our case, for example, policymakers would be interested to know the collective impact of drivers and barriers on the overall/combined green practices at the sector level), whereas operational level assessment would be similar to the subject teachers interest in knowing the factors affecting the subject level

IQ of the students in their respective subjects such as mathematics or social science (in our case the, for example, operation/implementation managers would be interested to know separately the individual impact of each driver and barrier on individual green practices), both important for the overall development of the child and, in our case, the greening the construction sector.

7.1 Strategic level assessment on the impact of green drivers and barriers on green practices

As stated previously, strategic level or high-level assessment involves assessing the relationships at the construct level (multi-dimensional conceptualization of several related items). It provides a high-level abstraction beyond the individual items and factors, or in simple terms, it looks at the collective impact of green drivers and barriers (external and internal) on green practices (external and internal).

Since this allows understanding the relationships at the sector level, this assessment is vital for policymakers and industry leaders to make informed, high-level decisions on actions, strategies and policy changes to strengthen the positive impact of drivers and/or weaken the negative impact of barriers.

For instance, this assessment would reveal whether the sector or stakeholders involved in the sector are reactive or proactive by looking at the strength of the relationship between external drivers and green practices and between internal drivers and green practices, i.e. the sector would be reactive if the external drivers exceed the internal drivers, and proactive if the internal drivers exceed the external drivers. While external drivers, as seen in other sectors, are important for changing the initial status quo of the sector for embracing green practices (Faisal, 2012), it is also seen that a reactive sector (driven mainly by external pressures) may not be sustainable in the long run (Walker et al., 2008) because reactive strategies are less likely to trigger green innovation in process and products (Vachon, 2007) or even worse, as it could be limited to 'corporate greenwash' or public relations exercises after the initial fuss (Walker et al., 2008). Realistically, therefore, it is important for the sector to have a right mix of both external (reactive) pressures and internal (proactive) pressures.

Also, in reality, different stakeholders in the same sector may behave differently (Walker et al., 2008) (i.e. reactively or proactively). Therefore, for the strategic level assessment for each stakeholder undertaken in this study, it is important to know whether the stakeholders (i.e., Developers, Architects/Consultants, Contractors, Suppliers) are reactive or proactive. Again, this understanding is critical for policymakers to develop mechanisms or policies to ensure 'diffusion of innovation' takes place from proactive stakeholders with the latest environmental practices to reactive stakeholders with low levels of environmental responsiveness so that all key stakeholders have adequate environmental capabilities and are equally involved and committed to environmental protection.

Similarly, knowledge of the strength of the relationship between external barriers and green practices, and between internal barriers and green practices across all stakeholders could enable policymakers to make priority interventions to eliminate/minimise either external and/or internal barriers for each stakeholder.

Overall, this knowledge on the relationships between green drivers, barriers and green practices could be used by policymakers and industry leaders to make prioritised actions, strategies and policy interventions to increase driving forces such as strengthening/tightening the government green-related regulation, enact/empower other external pressure groups such as NGOs, increase competition within the sector, such as by attracting more companies, especially foreign ones from advanced/developed countries to start operation in the country, increase buyer/customer awareness of the benefits of green buildings or environmental protection in general and provide government incentives and subsidies to encourage firms to implement green practices; and/or minimize/eliminate barrier forces such as encouraging local Universities to start sustainability programs, encourage foreign Suppliers to start operations in the UAE or encourage existing Suppliers to develop green products, regulate the timeline of projects (i.e. set minimize completion time requirements for green projects), and finally organize local and internal green/sustainability conferences, seminars, workshops and training activities to increase the overall knowledge and awareness of the sector in general.

As explained in chapter 3, the structured data collected through the survey will be used to assess these strategic level relationships including testing of hypotheses as shown in Table 7.1.

Table 7.1 Proposed research question and hypotheses on the impact of green drivers and barriers on green practices

Research question: How and to what extent do green drivers and barriers (external and internal) impact green practices (core and facilitating) for individual construction sector stakeholders (at the strategic level)?		
Proposed hypotheses (between green drivers and green practices)	H4.1	External drivers positively impact core green practices.
	H4.2	External drivers positively impact facilitating green practices
	H4.3	Internal drivers positively impact core green practices
	H4.4	Internal drivers positively impact facilitating green practices
Proposed hypotheses (between green barriers and green practices)	H4.5	External barriers negatively impact core green practices.
	H4.6	External barriers negatively impact facilitating green practices.
	H4.7	Internal barriers negatively impact core green practices.
	H4.8	Internal barriers negatively impact facilitating green practices.

The validity and reliability of each of these constructs in the study, i.e. the five first-order constructs, namely external green drivers, internal green drivers, external green barriers, internal barriers and facilitating green practices, and one second-order construct (core green practices) with several underlying first-order constructs (green design, green purchasing, green transportation, green construction/manufacturing and end of life green practices) was previously established in chapter 3.

7.1.1 Structural equation modelling and hypotheses test results

Path analysis (a special case of structural equation modelling) using factor scores extracted from the confirmatory factor analysis (CFA) was used to test the proposed hypotheses. A total of 32 relationships (hypotheses) were assessed across the four stakeholders (8 hypotheses for each stakeholder). The results of the path analysis for each stakeholder: Developer, Architect/Consultant, Contractor and Supplier are given in Table 7.2, 7.3, 7.4 and 7.5 respectively. The results show that 27 out of 32 hypotheses tested are supported. The overall model fit indices and goodness-of-fit indices obtained during the assessment of path analysis for each stakeholder were well above the acceptable threshold given in Table 3.8 (refer chapter 3).

Table 7.2: Hypotheses test results: Relationships between green drivers, barriers and practices (Developer)

	<i>Hypothesized path</i>			Standardized Estimate	Critical Ratio	Significance	Hypothesis supported
H4.1	External drivers	→	Core green practices	0.57***	4.92	0.000	Yes
H4.2	External drivers	→	Facilitating green practices	0.46**	2.17	0.034	Yes
H4.3	Internal drivers	→	Core green practices	0.42*	1.97	0.053	Yes
H4.4	Internal drivers	→	Facilitating green practices	0.17*	1.71	0.091	Yes
H4.5	External barriers	→	Core green practices	-0.18 ^a	1.25	0.216	No
H4.6	External barriers	→	Facilitating green practices	-0.34*	1.85	0.069	Yes
H4.7	Internal barriers	→	Core green practices	-0.22*	1.81	0.062	Yes
H4.8	Internal barriers	→	Facilitating green practices	-0.38*	1.83	0.067	Yes

***significance at $p < 0.001$; **significance at $p < 0.05$; *significance at $p < 0.1$; ^anon-significant test results

Table 7.3: Hypotheses test results: Relationships between green drivers, barriers and practices (Architect/Consultant)

	<i>Hypothesized path</i>			Standardized Estimate	Critical Ratio	Significance	Hypothesis supported
H4.1	External drivers	→	Core green practices	0.48**	3.00	0.003	Yes
H4.2	External drivers	→	Facilitating green practices	0.54**	3.30	0.001	Yes
H4.3	Internal drivers	→	Core green practices	0.64***	4.65	0.000	Yes
H4.4	Internal drivers	→	Facilitating green practices	0.54**	3.22	0.001	Yes
H4.5	External barriers	→	Core green practices	-0.26*	1.74	0.084	Yes
H4.6	External barriers	→	Facilitating green practices	-0.115 ^a	0.66	0.510	No
H4.7	Internal barriers	→	Core green practices	-0.09 ^a	0.61	0.591	No
H4.8	Internal barriers	→	Facilitating green practices	-0.11 ^a	0.59	0.611	No

***significance at $p < 0.001$; **significance at $p < 0.05$; *significance at $p < 0.1$; ^anon-significant test results

Table 7.4: Hypotheses test results: Relationships between green drivers, barriers and practices (Contractor)

	<i>Hypothesized path</i>			Standardized Estimate	Critical Ratio	Significance	Hypothesis supported
H4.1	External drivers	→	Core green practices	0.54***	4.08	0.000	Yes
H4.2	External drivers	→	Facilitating green practices	0.48***	3.80	0.000	Yes
H4.3	Internal drivers	→	Core green practices	0.74***	4.18	0.000	Yes
H4.4	Internal drivers	→	Facilitating green practices	0.62***	4.29	0.000	Yes
H4.5	External barriers	→	Core green practices	-0.33**	2.26	0.024	Yes
H4.6	External barriers	→	Facilitating green practices	-0.25*	1.76	0.077	Yes
H4.7	Internal barriers	→	Core green practices	-0.25*	1.91	0.056	Yes
H4.8	Internal barriers	→	Facilitating green practices	0.07 ^a	0.53	0.596	No

***significance at $p < 0.001$; **significance at $p < 0.05$; *significance at $p < 0.1$; ^anon-significant test results

Table 7.5: Hypotheses test results: Relationships between green drivers, barriers and practices (Supplier)

	<i>Hypothesized path</i>			Standardized Estimate	Critical Ratio	Significance	Hypothesis supported
H4.1	External drivers	→	Core green practices	0.58**	2.06	0.041	Yes
H4.2	External drivers	→	Facilitating green practices	0.26*	1.75	0.081	Yes
H4.3	Internal drivers	→	Core green practices	0.62**	2.31	0.022	Yes
H4.4	Internal drivers	→	Facilitating green practices	0.56**	2.08	0.039	Yes
H4.5	External barriers	→	Core green practices	-0.57**	2.11	0.037	Yes
H4.6	External barriers	→	Facilitating green practices	-0.13*	1.93	0.056	Yes
H4.7	Internal barriers	→	Core green practices	-0.18*	1.72	0.089	Yes
H4.8	Internal barriers	→	Facilitating green practices	-0.19*	1.78	0.078	Yes

***significance at $p < 0.001$; **significance at $p < 0.05$; *significance at $p < 0.1$

Relationship between green drivers and green practices: For the relationships between green drivers and green practices (H4.1 to H4.4), the evidence from the path analysis indicates that all four proposed hypotheses were supported for all four stakeholders (16 relationships in total), i.e. both external and internal drivers had a positive impact on both core and facilitating green practices across all stakeholders.

While it is encouraging to see from the standardized estimate or the path coefficient, which shows the strength of the relationships (1 being the highest and 0 being the lowest) that Contractors, Architects/Consultants and Suppliers are proactive in implementing green practices (strength of the relationship between internal drivers and green practices is higher than external drivers and green practices), the reactive nature of the Developers (strength of the relationship between internal drivers and green practices is lower than external drivers and green practices) is a concern, especially considering the fact that they are responsible for project initiation. It is an unwieldy task, therefore, in the hands of other stakeholders to encourage/motivate Developers to implement green practices.

However, as seen in the above tables, the strength of the impact of external and internal drivers on core and facilitating green practices is still moderate (between 0.3 and 0.7) in most cases or at times low [such as the relationship between external drivers and facilitating green practices for Suppliers (0.26) and the relationship between internal drivers and facilitating green practices (0.17) for Developers] with the only exception being the relationship between internal drivers and core green practices of Contractors (0.74). This shows that there is still plenty of scope for the sector to leverage the green drivers (both external and internal) to achieve extensive sector-wide implementation of green practices.

The important findings from an individual stakeholder perspective are as follows:

- **Developers:** As mentioned above, the reactive behaviour, as opposed to proactive behaviour, is a concern that the sector needs to address. Also, the findings in Table 7.2, warrant the need to closely look at the low impact of internal drivers to implement facilitating green practices ($\beta=0.17$, $p<0.1$).
- **Architects/Consultants:** As seen in Table 7.3, the results show that they are proactive,

especially with regards to the implementation of core green practices. The impact overall though, is still moderate; therefore, the sector should strive to enhance the impact, especially given the fact that they are close to Developers and their proactive behaviour can encourage Developers to implement green practices.

- **Contractors:** The results (Table 7.4) show that Contractors are very much proactive in the UAE construction sector. Ideally, in addition to pressurising Subcontractors and Suppliers, the sector would benefit if they were able to exert backwards pressure on Developers to implement green practices. Developers, on the other hand, could leverage the proactive attitude of Contractors by engaging them at the early stages of the project.
- **Suppliers:** Like Contractors, Suppliers are very much proactive in the sector as seen in Table 7.5. Although the impact of external drivers on facilitating green practices is low, ($\beta=0.26$, $p<0.1$), a closer evaluation of the extent of implementation of green practices (refer Table 4.7, chapter 4) shows that this is less of a concern given that the extent of implementation of facilitating green practices is already high ($M=4.3$, $SD=0.6$) because of their high internal drive to implement green practices.

Relationships between green barriers and green practices: For the relationships between green barriers and green practices (H4.5 to H4.8), the evidence from the path analysis as seen in tables 7.2-7.5 indicates that five out of the 16 hypotheses tested are not supported. As seen in the tables, the strength of the impact of external and internal barriers on the core and facilitating green practices in all cases is either moderate or low/non-existent. This is actually a positive indication for the sector and it shows that not all barriers have actually translated into organisational inactions in the UAE construction sector. However, given the fact that 11 out of 16 hypotheses are still significant shows more effort is required for the sector to eliminate or minimise the impact of barriers so that they are ineffective in preventing organisations from implementing green practices.

Stakeholder-specific findings on the impact of green barriers on green practices are as follows:

- **Developers:** Results in Table 7.2 show that there is no significant relationship between external barriers and the extent of implementation of core green practices for

Developers ($\beta=-0.18$, $p>0.1$). It appears as though this could be due to the fact that 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. The other relationships between green barriers and practices, though significant, are either moderate or low. This shows that the relatively low level of implementation of green practices, both core and facilitating (refer Table 4.7, chapter 4), could well be due to their relatively lower external and internal pressures/motives (refer Table 5.15, chapter 5).

- **Architects/Consultants:** As seen in Table 7.3, Architects/Consultants are the least impacted by barriers. Three out of the four relationships emerged to below and non-significant. The only significant relationship that emerged is the impact of external barriers on core green practices ($\beta=-0.26$, $p<0.1$). This shows that Architects/Consultants in the UAE are good at managing the barriers, especially given the fact that they do face barriers at a moderate level (refer Table 5.15, chapter 5).
- **Contractors:** As seen in Table 7.4, Contractors are impacted by barriers, as three out of the four relationships emerged to be significant, though from a low to moderate extent. As seen in table 5.15, this could be because they are facing relatively high barriers and/or they are not being able to manage them. Given their proactive approach to greening, any strategic or policy interventions to assist Contractors to overcome these barriers will further enhance their green practices implementation. Moreover, given that majority of the construction firms in the UAE are Contractors, any efforts to help them overcome the adverse impact of barriers could significantly contribute towards greening the sector.

- **Suppliers:** As seen in Table 7.5, among all the stakeholders, they are the most adversely affected by barriers, as all the four relationships between green barriers and practices emerged to be significant. Also, among all the 16 relationships assessed across all four stakeholders, the impact of external barriers on core green practices for Suppliers emerged as the highest $\beta=-0.57$, $p<0.01$.

Next, the relationships at the operational/implementation level are assessed.

7.2 Operational/implementation level assessment on the impact of green drivers and barriers on green practices

As stated before, operational/implementation level assessment involves assessing the relationships between green drivers, barriers and green practices at the individual item/factor level. It provides an in-depth, firm-level systemic understanding of the one-to-one impact of individual green drivers on individual green practices, and individual green barriers on individual green practices.

This understanding is critical because individual green drivers and barriers could impact each green practice's implementation differently, and that too could vary across stakeholders. As mentioned earlier, firms are not entirely powerless in terms of their ability to manage green drivers and barriers affecting their green practices implementation. Therefore, firms looking to improve any specific green practice can swiftly make sense of all key drivers and barriers impacting that green practice and therefore could choose to decide on prioritising actions for maximising/leveraging all or select green drivers and/or minimising/eliminating all or select green barriers impacting that green practice.

Practitioners responsible for implementing green practices (in their relevant department/functions) could use this finding to understand the relationships that are relevant for them. For example, government green-related regulation can impact purchasing decisions and onsite construction activities for Contractors. Therefore, purchase managers and project/site managers would know that they need to implement relevant green practices as mandated in the green regulation.

Similarly, the findings could also help government policymakers and industry leaders to evaluate the effectiveness of their actions, strategies and policy interventions in terms of their strength and ability to influence various green practices at the firm level.

As stated earlier in the methodology section (chapter 3), unlike the strategic level assessment, which used survey data, the implementation level insights on the causal relationship between green drivers, barriers and practices at the firm level require more in-depth investigation and multiple perspectives. Moreover, it is important to know the 'how' and 'why' aspect of the causal relationships. Therefore, focused, in-depth interviews were conducted to effectively capture the one to one relationships between green drivers, barriers and practices. The methodology used to qualitatively assess the relationships was already discussed in detail in Chapter 3.

Table 7.6 exhibits the one to one relationships between green drivers, barriers and practices at the operational/implementation derived from the qualitative investigation.

7.2.1 External drivers and green practices

Table 7.6 shows the relevant relationships identified between external drivers and green practices (core and facilitating) at the factor/item level for each stakeholder. The following subsections will discuss in sequence the individual impact of each external green driver on all core and facilitating green practices.

Government regulations and green practices: As seen in the table, government regulations were found to influence the green design and green purchasing practices of Developers. This was because any new project in the emirate of Dubai or Abu Dhabi (which covers 90% of all construction projects in the UAE) has to abide by the green building regulation. Developers also highlighted that they undertake projects in both Dubai and Abu Dhabi and therefore they have developed green expertise in design and purchasing to comply with both the regulations. Since government green building regulation (in both Abu Dhabi and Dubai) is a LEED design based framework with more emphasis on the design aspects of the building, the strength of impact (government regulation and green design) was obviously expected. Though government green building regulation does not directly specify the green purchasing practices of Developers, they were found to indirectly influence the green purchasing decisions of Developers. As seen in most

Table 7.6 Operational/implementation level relationships between green drivers, barriers and practices

✓ High Impact ✓ Moderate Impact Blank cell: Low/Negligible Impact

	External Drivers			Internal Drivers				External Barriers				Int. Barriers		Green Practices
	Government Regulations	Stakeholder pressure	Competitor Pressure	Environmental Commitment	Enhance Reputation/Brand image	Cost savings	Enter foreign markets	Shortage of green professionals	Shortage of local green material suppliers	Tight and inflexible stakeholder deadlines	Lack of stakeholder collaboration	Lack of knowledge and awareness of green	High cost of implementation	
Developer	✓		✓	✓	✓		✓	✓	✓			✓	✓	Green design
	✓		✓	✓	✓		✓	✓				✓	✓	Green purchasing
												✓		Green transportation
			✓	✓	✓		✓	✓				✓	✓	End of life green practices
			✓	✓	✓		✓	✓				✓	✓	EMS & ISO 14001
			✓	✓	✓			✓				✓	✓	Environmental training
			✓	✓	✓			✓				✓	✓	Environmental auditing
				✓	✓									Cross-functional Integration
Architect/Consultant		✓	✓	✓	✓		✓	✓	✓	✓		✓		Green design
				✓	✓									Green transportation
		✓	✓		✓		✓	✓		✓	✓			End of life green practices
		✓	✓	✓	✓		✓	✓				✓		EMS & ISO 14001
		✓	✓	✓	✓		✓	✓			✓		✓	Environmental training
		✓	✓	✓	✓		✓	✓			✓		✓	Environmental auditing
			✓	✓										Cross-functional Integration
			✓	✓	✓		✓	✓			✓		✓	Green-related R&D
Main/Sub-Contractor		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	Green purchasing
				✓	✓	✓						✓	✓	Green transportation
	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	Green construction
		✓	✓	✓	✓			✓		✓	✓			End of life green practices
	✓	✓	✓	✓	✓		✓	✓				✓	✓	EMS & ISO 14001
		✓	✓	✓	✓		✓	✓				✓	✓	Environmental training
		✓	✓	✓	✓		✓	✓				✓	✓	Environmental auditing
				✓		✓						✓		Cross-functional Integration
Supplier		✓	✓	✓	✓		✓		✓	✓	✓		✓	Green (material) design
				✓	✓			✓				✓		Green purchasing
				✓	✓				✓	✓				Green transportation
		✓		✓	✓	✓	✓		✓			✓		Green manufacturing
				✓	✓		✓					✓		EMS & ISO 14001
				✓	✓		✓					✓		Environmental training
				✓	✓		✓					✓		Environmental auditing
				✓	✓									Cross-functional Integration
			✓	✓		✓				✓		✓	Green-related R&D	

Note: Consumer pressure is not included in the table as it was found to have no influence on any of the Developers green practices

cases, Developers do not have the expertise or the resources to completely undertake the green design responsibility. Therefore, they have to procure the services of Architects/Consultants for green building design. Hence, responsibility for meeting the government green building regulation is passed on to Architects/Consultants in the form of purchase contracts. The impact of government regulation on the green purchasing practices of Developers can be summarised in the words of an interviewee:

“...we had to revamp our entire purchasing policies in 2011 to comply with green building regulations”

However, government regulation was found to have no influence on any of the other core or facilitating green practices.

On the other hand, as seen in the table, government regulation was found to have no influence on the green practices of Architects/Consultants. This is because stakeholders specified in the government regulation are only the Client (Developer) and the Contractor.

For Contractors, government regulation was found to impact only two green practices, the onsite construction activities (green construction) and EMS and ISO 14001. As mentioned earlier, this was because government regulations require Contractors to divert at least 50% of onsite landfill waste by volume or weight. Moreover, in Abu Dhabi, Contractors have to prepare a comprehensive Construction Environmental Management Plan (CEMP), which includes construction and waste management plan (CDWMP). The CDWMP must identify the materials to be diverted from landfill and indicate whether the materials will be segregated on-site or co-mingled. If materials are planned for reuse, the plan must indicate their planned use. All Contractors are required to demonstrate that they implemented monthly monitoring of the CDWMP. The interviewees also highlighted the relatively higher landfill tax in Abu Dhabi (approx. US\$ 60 per tonne of waste as compared to US\$ 3 in Dubai and zero landfill charge in other emirates) to positively impact their onsite waste management practices. Also in Abu Dhabi, it is mandatory for Contractors involved in the construction project to implement EMS and achieve certification from either ISO 14001 or the Abu Dhabi environmental health and safety management system. In addition, respondents also highlighted Federal Law No. (24) for 1999 for

the Protection and Development of the Environment relating to the permissible limits on noise and air pollution during onsite construction activities.

For Suppliers, though there is no direct government regulation, respondents highlighted that material specifications such as recycled content, thermal characteristics and energy consumption, mentioned in the government regulation, have impacted their green design and green manufacturing practices. Moreover, Suppliers interviewed anticipate more stringent environmental regulations on building materials in the near future and also anticipate a government pre-approved list of products and material manufacturers. For instance, one respondent pointed out the recently introduced regulation on the use of cladding in buildings in the wake of increasing number of cases of building fires reported in the UAE. As per the new regulation, any cladding used in the building shall be certified to be capable of preventing fire and related toxic emissions. Overall, government regulation was found to have an indirect impact on the green design and green manufacturing of Suppliers.

Stakeholder pressure and green practices: As seen in the table, none of the green practices for Developers is driven by the pressure from other stakeholders. Though some Architects/Consultants are making concerted efforts to convince Developers to implement green projects, this friendly peer pressure was not sufficient to change the green behaviour of Developers who sits at the top of the hierarchy. On the contrary, stakeholder pressure from Developers was found to influence the green practices of other stakeholders. As seen in the table, stakeholder pressure from Developers was found to significantly influence the green design practices of Architects/Consultants. This was not surprising considering the fact that regulatory pressure faced by the Developers is passed on to Architects/Consultants. Also, Developers are opting for more LEED certified projects, which is impacting the Architects/Consultants green design practices. This increasing pressure to meet the Developer's higher green requirements was found to be one of the main reasons for Architects/Consultants to implement EMS and ISO 14001, environmental training and environmental auditing. As evidenced from the interviews, these practices are also driven out of fear, as failure to meet the green expectations of Developer could lead to them being blacklisted or not considered for future projects of the Developer. Further, increasing scrutiny of the capability of Architects/Consultants to undertake green

projects is also driving their green practices such as EMS and ISO 14001, as failure to do so may lead to them not winning the project in the first instance.

In the case of main Contractors, except for practices such as green transportation, cross-functional integration and R&D, Developer pressure was found to impact the rest of the core and facilitating green practices. The main Contractors, on the other hand, were found to contractually pass on the green requirements to the Subcontractors, who in turn were found to pressurise their Subcontractors. The impact of main Contractor pressure on green practices was significant for Subcontractors, who rely on a few large Contractors for their business. Any non-compliance in green aspects could lead them to be removed from the main Contractors list of preferred Subcontractors.

Suppliers, as evidenced from the interviews, face more pressure from Architects/Consultants than Contractors. Given the Architects/Consultants strong role in the tender specification including green aspects, any Supplier product requires approval by the Architect/Consultant, who in turn was found to demand several green attributes such as the embodied energy and recycled content. Suppliers, therefore, are forced to implement green design and green manufacturing practices to get into the tender list as one of the approved vendors for green projects.

Competitor pressure and green practices: Among the other external drivers, competitor pressure was identified to have a broader impact on the green practices of stakeholders except for Suppliers. Respondents from Developers highlighted their fear of losing competitive advantage and market share as one of their main reasons for implementing green practices. In the words of an interviewee (Developer):

“Sustainability is the future, and soon everybody will be talking about it and we need to be ahead of the game”.

The need to meet or exceed the green practices of competitors has impacted Developers green practices, especially their green design and green purchasing practices as well as their facilitating practices, namely EMS and ISO 14001, environmental training and auditing practices.

For Architects/Consultants as mentioned earlier, competitor pressure is high because of the increasing number of foreign Architects/Consultants establishing their branch offices in the UAE as well due to increasing overseas consultants bidding for UAE projects. Respondents highlighted their need to be competitive in green aspects to survive in the market. Given the fact that some of the Developers are selecting Architects/Consultants for green projects based on green design, competition stresses the impact of competitor pressure on green design. One of the foreign Architects/Consultants also emphasised the need to innovate and promote practices, such as the end of life green practices, to achieve competitive advantage among others.

A similar scenario was found for Contractors as well. Competitor pressure was found to impact all their green practices except for green transportation, cross-functional integration and R&D. The increasing number of foreign and foreign-local joint venture Contractors is highlighted as one of the main factors prompting Contractors, especially local ones, to implement green practices. According to a respondent from a local Contractor, increasing numbers of joint venture firms is a major concern as they possess the combined advantage of foreign firms' environmental expertise and local firms' local connections, contacts, and deep understanding of specific conditions of the UAE market. Further, the heightened scrutiny by Developers on the Contractors' green capabilities shows the importance of implementing green practices to stay competitive in the market.

For Suppliers though, competitor pressure was found to impact only the green design due to green product imports to the UAE. According to the commercial office of the Chinese consulate in Dubai, Chinese imports to the UAE, which are largely driven by the construction sector, are expected to reach \$350-\$500 billion in 2020 and therefore will continue to pose a significant challenge to Suppliers in the UAE (Construction week, 2010).

Consumer pressure (relevant only to Developers) was not included in the table since it was found to have no impact on any of the green practices of Developers.

7.2.2 Internal drivers and green practices

Table 7.6 shows the important relationships identified between internal drivers and green practices at the factor/item level. The following subsections will discuss in sequence the individual impact of each internal green driver on all core and facilitating green practices.

Environmental commitment and green practices: As seen in the table, the environmental commitment was found to impact most/all green practices across each stakeholder. This is not surprising given that environmental commitment of firms is dedicated towards organisational wide excellence in every aspect of their operation rather than focusing on a few green practices. As mentioned in Chapter 5, while discussing environmental commitment as a driver, several firms have environmental commitment embedded in their vision and mission statement. Moreover, the scope of corporate environmental policies and practices reviewed are broad and cover a range of issues.

Enhance brand reputation/brand image and green practices: As seen in the table, this relationship was also found to impact most of the green practices across all stakeholders. It was evident from the interviews that firms that are looking to enhance brand reputation are looking to implement a diverse range of practice to gain marketing benefits by receiving the attention/recognition of media and investors.

Cost reduction and green practices: For Developers, cost saving as a driver was found to impact only the green design practice. Interviewees acknowledged that green buildings require fewer materials per unit area than conventional materials. Also, they highlighted that green design significantly improves constructability, thereby by reducing construction waste and construction time. Moreover, Developers, especially the resident builders (who still hold ownership of common areas even after selling all apartment units), who are responsible for managing the common areas of the building, highlighted the benefits of reduced water and energy consumption to them as well as to the tenants from green design. In the words of a respondent:

“even small aspects such as reducing the flow rate of the shower head or tape, or using light sensors in corridors can bring significant cost savings, much higher than what you can imagine”.

In the case of Contractors, as expected, cost saving was found to drive green construction practices. However, it was interesting to discover that cost saving was also driving green transportation and cross-functional integration. According to respondents, proper transportation planning of both employee and materials can significantly reduce the number of trips required during construction activities. Interviewees, however, did admit that this is one aspect that is often overlooked in construction despite significant cost implications in fuel, vehicle maintenance and personnel (such as truck drivers). One contractor highlighted the significant lost time of employees (hundreds of onsite workers) due to road traffic conditions. Providing employee accommodation near project sites was found to significantly reduce transportation related costs and lost time. It was also found that the intention to reduce cost was also behind the cross-functional integration of departments. For example, one of the interviews highlighted an instance in which the onsite project manager requested the purchasing team to make an additional 'take back' clause during material purchase to reduce excess material wastage. This is especially important when the material used is unique to that particular project and that Contractors may not be able to use it in other projects. For Suppliers though, cost reduction as a driver was found to influence only green manufacturing. Despite the high upfront investment, respondents highlighted significant cost benefits through reduced material usage, wastage, energy and water consumption.

Enter foreign market and green practices: As seen in the table, enter foreign market as a driver was found to impact several green practices across each stakeholder. This was not surprising given that each country has its own set of green regulations; therefore, firms looking to enter multiple markets are required to comply with each government regulation, and consequently have to implement a broad range of practices to comply with. For example, stakeholders looking to enter developed countries such as US and UK have to comply with a broad range of green practices because of the stringency of government regulation in those countries. Further, the environmental expectations of business partners and investors were also found to vary across different countries leading to the implementation of different green practices by firms. For example, one Developer mentioned that in one of their projects in the US, they were asked to demonstrate the end of life green practices plan for the building even before the project started.

7.2.3 External barriers and green practices

Table 7.6 shows the relevant relationships identified between external barriers and green practices at the factor/item level. The following subsections will discuss in sequence the individual impact of each external green barrier on all core and facilitating green practices.

Shortage of green professionals and green practices: As seen in the table, shortage of green professionals was found to impact most of the green practices except for green transportation and cross-functional integration for Developers, Architects/Consultants and Contractors. While the reasons outlining the shortage of green professionals are mentioned in Chapter 5, from a theoretical perspective, the broad impact of the shortage of green professionals on green practices can be explained using resource and knowledge based view. As highlighted by respondents, most green practices are resource and knowledge intensive. This also explains why the shortage of green professionals was found not to impact green transportation and cross-function integration, since they are less resource and knowledge intensive. In the case of Suppliers, none of their green practices was impacted by the shortage of green professionals because it was evidenced from the interviews that they could easily attract professionals from other industries such a general manufacturing. Also, material manufacturing is more standardised and less rigorous than onsite construction. Moreover, as mentioned in Chapter 5, Suppliers rely less on human resources, as they are more technology/equipment dependent.

Shortage of local green suppliers and green practices: The shortage of local green suppliers and green practices was found to impact the green design and green purchasing practices of Developers. One of the reasons stressed by respondents is that many of the green material/product/equipment required for green buildings/LEED certification is not available in the UAE. According to the respondents, sourcing materials from countries such as the US, UK and Germany is expensive and time-consuming, delaying the overall project duration. Also, the emissions associated with the shipment of these materials do not serve a green purpose. Moreover, warranty claims and service maintenance /repair of these products are not available in the UAE. For these reasons, Developers are to some extent reluctant to choose to innovate green design and add stringent environmental criteria during procurement.

Lack of local green suppliers was also found to impact the green design practices of Architects/Consultants, especially that of foreign ones. For example, foreign Architects/Consultants building design is usually based on foreign Suppliers (whom they are familiar with), whereas, local Developers prefer local Suppliers and most often this was found to create conflicts that lead to design revisions and variations before and after the start of the project. In the case of Contractors, lack of local green Suppliers was found to impact their green purchasing. This is because, Contractors, especially the local ones interviewed, acknowledge their reluctance to purchase from foreign Suppliers. The lack of reluctance to deal with foreign Suppliers means that the environmental criteria in purchasing decisions are often relaxed to select local Suppliers. The main reason for reluctance evident from the interviews is the repayment time period and lack of credit facility. According to the respondents, the typical repayment period for local Suppliers is 90 to 180 days with a decent credit facility, whereas for foreign Suppliers it is mostly 50% advance and 50% on delivery with no credit facility. Moreover, respondents highlighted the risk of delay in these imported materials as they have little or no legal control or bargaining power with foreign Suppliers. Also, respondents highlighted that product exchange or product return with foreign Suppliers is difficult to impossible. This can be summarised in the words of two interviewees:

“There is uncertainty while switching suppliers, especially from local to foreign”

“..... this challenge is even more so when we deal with foreign Suppliers”

In the case of Suppliers, lack of local green suppliers has been highlighted as a concern for coming up with innovative green material/product design. According to respondents, there are only a few local raw material suppliers in the region. This also means that they were unable to impose stringent environmental criteria in the procurement terms and conditions. The other concern highlighted by Suppliers was the lack of availability of local manufacturing equipment supplies. In most cases, Suppliers had to rely on imported green manufacturing equipment from countries such as Germany and France, which first of all are very expensive. Moreover, Suppliers are left with no option but to sign annual maintenance contracts and extended warranties with the manufacturer directly, and for any breakdown/claims, the green equipment suppliers were found to mostly fly in and fly out their professionals, leading to downtime and expenses.

Tight and inflexible stakeholder deadline and green practices: This was found to impact the green design practices of Architects/Consultants. According to respondents, this is mainly because green design is a time-consuming process and often tight deadlines are the cause of trade-offs leading to non-optimal design solutions. This was also the case with the end of life green practices of buildings. In most cases, Consultants were given insufficient time for planning and execution of the demolition work leading to a trade-off in the recovery of materials.

In the case of Contractors, the tight and inflexible deadline was found to have a broader impact on green purchasing, green construction and end of life green practices. According to the respondents, green purchasing actions are time-consuming, especially given the fact that they deal with hundreds of diverse Subcontractors and Suppliers. Therefore, close scrutiny of Subcontractors and Suppliers on green aspects is compromised due to the tight and inflexible stakeholder deadline. Similarly, Contractors highlighted that onsite preparation processes and procedures for green construction activities, such as waste management, requires more time than conventional construction processes. Therefore, tight deadlines and associated penalties for delays are to some extent compelling them to restrain from green construction practices. In any case, delay in project completion can cause cost-overflow for Contractors in terms of continuing onsite superintendence, security, and cost of running temporary facilities such as site office. Similar issues were also reported by Contractors while undertaking end of life demolition activities.

In the case of Suppliers, tight and inflexible stakeholder deadlines were to some extent found to impact their green design practices. This is because the interviewed Suppliers highlighted the possibility of supplying customised materials for projects provided they are given enough time for design and delivery. Also, respondents highlighted that tight deadlines have adversely impacted their green transportation planning (delivery in full truck quantities) and choosing an appropriate time for delivery (during off-peak traffic hours).

Lack of stakeholder collaboration and green practices: This was found to have no impact on any of the Developers green practices. This is because they were found to have control over the nature and extent of collaboration with (downstream) stakeholders.

However, for Architects/Consultants, lack of stakeholder collaboration from Developers was found to impact all of their green practices except for green transportation and cross-functional integration. The underlying aspects relating to the impact of lack of stakeholder collaboration on green design is discussed in Chapter 5. In addition, Consultants highlighted the reluctance of Developers to listen to their end of life green practices plan to maximise recovery of materials. Similarly, Architects also highlighted the hesitancy of Developers to incorporate design aspects that maximise end of life recoverability of materials. Furthermore, lack of stakeholder collaboration was found to impact their external training and auditing activities. For example, interviewees highlighted the poor participation in the environmental training programs from Developer and Contractor employees. Similarly, Architects/Consultants also highlighted the lack of cooperation from some Contractors while conducting environmental audits. In addition, Architects/Consultants pointed out the lack of collaboration and funding from Developers for conducting joint R&D for innovate design, which is common in developed countries such as US and UK.

In the case of Contractors, lack of stakeholder collaboration was found to impact green purchasing, green construction and end of life green practices. As highlighted in Chapter 5, lack of collaboration was found to prevent them from using materials greener than those specified in the tender documentation. In addition, lack of collaboration was identified as the source of other issues such as project variation, project delay due to logistics issues, role conflict from ambiguity in the tender specifications and compatibility issues of green systems with other systems in the building. The importance of early stakeholder engagement can be summarised in the words of one of the Contractors:

“We should be involved, in fact from the pre-design stage”, because an “Architects dream is an engineers (Contractors) nightmare”.

For Suppliers, lack of stakeholder collaboration was found to impact their green product design. Lack of early engagement and lack of long-term collaboration are the two main reasons highlighted by respondents that are stopping them from knowing the Developers’ project needs and, if required, customising green materials for projects. This is also the reason impacting their research and development activities. According to respondents, joint collaborative research and

development with both Developers and Contractors would be useful in developing innovative green products. Also, lack of collaboration was also found to impact their green transportation activities. For example, one respondent highlighted the refusal of a Contractor to receive materials onsite during out of office hours or weekends, which was proposed by the Supplier to avoid road traffic conditions. In addition, Suppliers highlighted Contractors requesting part delivery of materials (due to lack of onsite storage facilities) leading to an increase in the number of round trips for them. In the words of one of the interviewees:

“Sometimes we are forced to deliver the materials in like ten parts, where it should have been just one”

7.2.4 Internal barriers and green practices

Table 7.6 shows the important relationships identified between internal barriers and green practices at the factor/item level. The following subsections will discuss in sequence the individual impact of each internal green barrier on all core and facilitating green practices.

Lack of knowledge and awareness and green practices: As seen in the table, for Developers, lack of knowledge and awareness was found to have a broad impact on all the core and facilitating green practices (except cross-functional integration). For instance, one of the Developer interviewees highlighted the following reason for their reluctance to use green materials:

“...existing studies on green materials that can save money to Developer in projects are very weak and no comprehensive studies are readily available for comparison purposes.....people are ill-aware about the benefits of green products...”

Also for Contractors, lack of knowledge and awareness was found to impact all the green practices. Some of the underlying reasons are similar to those discussed in chapter 5 (refer section 5.2.2.2).

On the contrary for Architects/Consultants and Suppliers, lack of knowledge and awareness was found to have no specific impact on any of the green practices. As discussed in chapter 5 (refer section 5.2.2.2), this is because their knowledge and awareness level in general on green/environmental aspects was higher than Contractors and Suppliers.

The high cost of implementation and green practices: As seen in the table, the high cost of implementation, in general, was found to impact most of the green practices across all stakeholders. For Developers, the impact was found to be especially high for small firms. In the words of an interviewee (small Developer):

“governments and giant Developers have taken the lead to construct environmentally friendly projects as they can afford the cost. When it comes to private developments, cost is of essence as budgets are usually very tight”

In the case of Suppliers, the broad impact of high cost of implementation on green practices could be because the green products are more expensive than conventional products, which in turn could explain why green projects are more expensive than conventional projects (as approximately 60% of total cost of the project is material cost).

Overall, the general perception across respondents was that all stakeholders and governments have to work together to bring down the cost of green building projects. This is captured in the words of one respondent (Architect/Consultant), though there is some optimism:

“...a great push, for example, is the banning of incandescent bulbs and neon tube lights and the obligation to use instead LED bulbs and LED tube lights. The prices of LED bulbs and tubes are still way more expensive than the traditional incandescent bulbs or neon tube lights but they have become more affordable recently”.

7.2.5 Key implications from the operational/implementation level assessment

Some of the important implications evident from the findings in Table 7.6 are as follows:

- Not all drivers and barriers impact all green practices.
- Individual green drivers and barriers could impact each green practice differently (high, medium, low/no impact) and that too could vary across stakeholders.
- Some green drivers and barriers impact several green practices (broad impact), while others impact few green practices (narrow impact). For example, green drivers, such as regulations and cost savings, affect the implementation of only a few green practices and for select stakeholders, while there are other drivers, like environmental commitment and enhance reputation/brand image, where the effect is on several green practices’

implementation, and for several stakeholders. A similar contrast is seen for the barriers as well. Firms could utilise this knowledge to identify and prioritise strategies for those drivers and barriers that have a strong and broad impact on green practices implementation.

- Some green practice (such as green design for Architects/Consultants and green construction for Main/Sub-Contractors) implementation is influenced by several drivers and barriers; much careful thought, therefore, would be needed when considering applying such practices. Others, such as green-related R&D for Developers and green transportation for Suppliers are, however, influenced by only a few green drivers and barriers; therefore, it would be easier to decide on their implementation.
- Overall from a practical perspective, green practice implementation can be enabled by working only on the drivers and leveraging them, or working only on the barriers and mitigating them, or using an in-between approach of leveraging some drivers and mitigating some barriers; the choice could be based on economic logic and ease of implementation. This can be expected to work both at an individual firm level as well as for the sector as a whole, where the extent of implementation of a green practice would be the focus and of interest to policy-makers.

To summarize, the strategic and operational/implementation level findings on the impact of green drivers and barriers on green practices is expected to enhance the ability of construction firms and the sector in general to better manage these antecedents (i.e. in leveraging the impact of drivers and minimizing/eliminating the impact of barriers) for sector-wide implementation of green practices. Overall, this chapter comprehensively answers the research question (RQ4) proposed in this thesis. A comprehensive assessment on this scale and depth has not been undertaken previously in any sector, let alone construction, and therefore adds to the novelty of this thesis.

Chapter 8- Impact of Green Practices on Green Performance

Chapter 6 discussed the extent of performance improvement (overall) of each green performance dimension (environmental, economic/cost and organisational). While this is useful in its own right, in line with our research question (RQ5), the objective of this chapter is to understand the separate impact of core and facilitating green practices (extents of implementation) on the environmental, economic/cost and organisational performance improvement.

Like the previous chapter, two levels of assessments, strategic and operational level assessment are carried out to develop a comprehensive understanding of the causal relationships between green practices and green performance that could help enhance the overall greening of the sector. Again, the logic of having these two assessments is simple.

First, strategic level assessment (collective impact of core green practices on each green performance and collective impact of facilitating green practices on each green performance) allows understanding the relationships at the sector level. For policymakers and industry leaders, this would enable them to assess to what extent the 'implementation of core and facilitating green practices have translated into green performance in the sector. This understanding is critical because the high extent of green practices implementation does not necessarily translate into high performance, though ideally, all the efforts to implement green practices should translate to performance. A metaphoric comparison would be saying 'spending long hours preparing for exams does not necessarily mean high grades, though it is widely expected to be'. Therefore, this strategic level assessment would help the sector to gauge the efficiency and effectiveness of green practices implementation and hence actions, strategies and policy interventions could be appropriated to improve the efficiency and effectiveness of green practices implementation.

The operational/implementation level assessment is important to understand the relationships at the firm level. For firms, knowing the role and contribution of (individual) green practices on each dimension of performance would enable practitioners to prioritise the implementation of those facilitating and/or core green practices that deliver the firm's desired green performance

goals (taking all three performance aspects into consideration). Metaphorically, this would be like knowing how the time spent studying in classrooms, at home, at the library etc. (in our case different green practices) have separately impacted the overall grades for arts, science and mathematics (in our study each dimension of performance). The following sections will discuss the findings from the strategic and operational/implementation level assessment on the impact of green practices on green performance.

Further, relevant management/organisational theories (wherever applicable) will be used to understand the relationships better.

8.1 Strategic level assessment on the impact of green practices on green performance

As stated before, strategic or high-level assessment examines the collective impact of green practices (core and facilitating) on green performance (environmental, economic/cost and organisational).

Ideally, both core and facilitating green practices should impact all three dimensions of green performance, namely environmental, cost/economic and organisational performance in the construction sector. As stated previously, the literature from other sectors on the relationship between green practices and different dimensions of performance is mixed. Therefore, this assessment is important for the sector to know the 'win-win's', and/or the tradeoffs that exist for each stakeholder with regards to the performance from green practices implementation. Also, as mentioned earlier in this chapter, the strategic level assessment helps the sector to assess the efficiency and effectiveness of core and facilitating green practices implementation.

In reality, the impact of green practices on performance would be different for different stakeholders. For policymakers and industry leaders, this assessment is therefore important to manage the conflicting interests of different stakeholders in the supply chain.

As explained in the methodology in chapter 3, the structured data collected from the country-wide survey will be used to assess the strategic level relationships including testing of hypotheses as shown in Table 8.1.

Table 8.1 Proposed research question and hypotheses on the impact of green practices on performance

Research question: How and to what extent do green practices (core and facilitating) impact green performance (environmental, cost/economic and organisational) for individual construction sector stakeholders (at the strategic level)?		
Proposed hypotheses (between core green practices and green performance)	H5.1	Core green practices positively impact environmental performance.
	H5.2	Facilitating green practices positively impact environmental performance
	H5.3	Core green practices positively impact economic performance
Proposed hypotheses (between facilitating green practices and green performance)	H5.4	Facilitating green practices positively impact economic performance
	H5.5	Core green practices positively impact organisational performance
	H5.6	Facilitating green practices positively impact organisational performance

The validity and reliability of each of these four first-order constructs, namely facilitating green practices, environmental performance, economic/cost performance and organisational performance and one second-order construct, core green practices, was previously established in chapter 3.

8.1.1 Structural equation modelling and hypotheses test results

Similar to the approach used in the previous chapter (chapter 7), path analysis was used to test the proposed hypotheses. A total of 22 relationships (hypotheses) were assessed across four stakeholders (six hypotheses for Developers, Contractors and Suppliers, and four hypotheses for Architects/Consultants). The results of path analysis for each stakeholder are given in Tables 8.2-8.5. The results indicate that 21 out of 22 hypotheses tested are supported. The overall model fit and goodness-of-fit indices obtained during the assessment of path analysis for each stakeholder were well above the acceptable limit given in Table 3.8 (refer chapter 3). The standardised estimate or the path coefficient represents the strength of the relationships (1 being the highest and 0 being the lowest), i.e. it shows to what extent the green practices implementation has contributed to performance, with 1 being the ideal score.

The relationship between core green practices and green performance: As seen in Tables 8.2-8.5, 10 out of the 11 proposed hypotheses are supported. The only relationship that emerged not significant is the impact of core green practices on the economic/cost performance ($\beta=-0.21$, $p>0.1$) for Developers. The strength of the relationships between core green practices and

Table 8.2 Hypotheses test results: Relationships between green practices and performance (Developer)

	<i>Hypothesized path</i>			Standardized Estimate	Critical Ratio	Significance	Hypothesis supported
H5.1	Core green practices	→	Environmental performance	0.78**	2.56	0.013	Yes
H5.2	Core green practices	→	Cost/Economic performance	0.21 ^a	0.38	0.703	No
H5.3	Core green practices	→	Organisational performance	0.78**	2.53	0.014	Yes
H5.4	Facilitating green practices	→	Environmental performance	0.79**	2.48	0.016	Yes
H5.5	Facilitating green practices	→	Cost/Economic performance	0.84**	2.59	0.012	Yes
H5.6	Facilitating green practices	→	Organisational performance	0.75**	2.99	0.004	Yes

***significance at $p < 0.001$; **significance at $p < 0.05$; *significance at $p < 0.1$; ^anon-significant test results

Table 8.3 Hypotheses test results: Relationships between green practices and performance (Architects/Consultant)

	<i>Hypothesized path</i>			Standardized Estimate	Critical Ratio	Significance	Hypothesis supported
H5.1	Core green practices	→	Environmental performance	0.70***	4.81	0.000	Yes
H5.2	Core green practices	→	Cost/Economic performance	NA			
H5.3	Core green practices	→	Organisational performance	0.38***	4.30	0.000	Yes
H5.4	Facilitating green practices	→	Environmental performance	0.71***	4.78	0.000	Yes
H5.5	Facilitating green practices	→	Cost/Economic performance	NA			
H5.6	Facilitating green practices	→	Organisational performance	0.55***	3.80	0.000	Yes

***significance at $p < 0.001$; **significance at $p < 0.05$; *significance at $p < 0.1$; ^anon-significant test results

Table 8.4 Hypotheses test results: Relationships between green practices and performance (Contractor)

	<i>Hypothesized path</i>			Standardized Estimate	Critical Ratio	Significance	Hypothesis supported
H5.1	Core green practices	→	Environmental performance	0.70***	4.03	0.000	Yes
H5.2	Core green practices	→	Cost/Economic performance	0.51***	4.39	0.000	Yes
H5.3	Core green practices	→	Organisational performance	0.49***	4.26	0.000	Yes
H5.4	Facilitating green practices	→	Environmental performance	0.64***	4.48	0.000	Yes
H5.5	Facilitating green practices	→	Cost/Economic performance	0.50**	3.13	0.002	Yes
H5.6	Facilitating green practices	→	Organisational performance	0.45***	3.40	0.000	Yes

***significance at $p < 0.001$; **significance at $p < 0.05$; *significance at $p < 0.1$; ^anon-significant test results

Table 8.5 Hypotheses test results: Relationships between green practices and performance (Supplier)

	<i>Hypothesized path</i>			Standardized Estimate	Critical Ratio	Significance	Hypothesis supported
H5.1	Core green practices	→	Environmental performance	0.84***	4.17	0.000	Yes
H5.2	Core green practices	→	Cost/Economic performance	0.56**	3.14	0.002	Yes
H5.3	Core green practices	→	Organisational performance	0.62**	3.01	0.003	Yes
H5.4	Facilitating green practices	→	Environmental performance	0.74***	4.76	0.000	Yes
H5.5	Facilitating green practices	→	Cost/Economic performance	0.74***	4.76	0.000	Yes
H5.6	Facilitating green practices	→	Organisational performance	0.67***	4.27	0.000	Yes

***significance at $p < 0.001$; **significance at $p < 0.05$; *significance at $p < 0.1$; ^anon-significant test results

green performance in general across stakeholders has been moderate to high. Specifically, the impact of core green practices on environmental performance has been high (path coefficient of 0.7 or higher) for all stakeholders. While the positive impact of core green practices on environmental performance was expected (because the *raison d'être* for implementing green practices is that it should improve a firm's environmental performance), it is the (high) strength of impact that is encouraging for the sector and cast off any doubt among practitioners in the construction sector that environmental performance from green practices may not be guaranteed. This is in line with the findings in other sectors, such as manufacturing, which reported improvement in environmental performance from implementing related core or external green practices (Zhu et al., 2012b).

Although the impact of core green practices on economic/cost performance was not significant for Developers, its impact was found to be moderate for Contractors and Suppliers. While the literature is still debating the ability of green practices to improve economic/cost performance (Zhu et al., 2012), the study findings are encouraging for Contractors and Suppliers for the implementation of core green practices. Since economic/cost performance is not relevant for Architects/Consultants, the relationship is not applicable and therefore not assessed.

Yet, the most interesting findings are the impact of core green practices on organisational performance, which was found to be high for Developers ($\beta=0.78$, $p<0.05$) and moderate for other stakeholders. This shows that "being green pays" in the long run, and should therefore encourage other firms, especially Developers, who are doubtful about the long-term benefits of implementing core green practices.

The relationship between facilitating green practices and green performance: As seen in Tables 8.2-8.5, all 11 proposed hypotheses are supported. This shows that facilitating green practices had a direct impact on all three dimensions of performance. Further, the strength of the impact has been moderate to high across stakeholders.

Specifically, looking at the impact of facilitating green practices on each dimension of performance, the findings in the tables show that facilitating green practices had a high impact on environmental performance for all stakeholders ($\beta>0.7$, $p<0.001$), except for Contractors,

which is still moderately high ($\beta=0.64$, $p<0.001$). This should provide firms not only in construction, but in other sectors, looking to improve their environmental performance to implement facilitating green practices.

As regards the impact of facilitating green practices on economic/cost performance, the findings are again encouraging for the sector, as facilitating green practices were found to have a high impact on economic/cost performance for all relevant stakeholders ($\beta>0.7$, $p<0.05$), except for Contractors, which is still moderately high ($\beta=0.50$, $p<0.05$). This clearly demonstrates the cost-saving potential of facilitating green practices, especially when there is little consensus in the literature that facilitating green practices could lead to improved economic/cost performance. As mentioned earlier, since economic/cost performance is not relevant for Architects/Consultants, this relationship is not applicable and therefore not assessed.

Yet again, the important findings are the high impact of facilitating green practices on organisational performance for Developers ($\beta=0.75$, $p<0.05$) and moderate impact for other stakeholders. Overall, 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.

To summarize, the results show that there are significant “win-win” opportunities for firms that seek to implement green practices and therefore should provide the impetus for practitioners in the UAE construction sector to implement green practices. Next, the relationships at the operational/implementation level are discussed.

8.2 Operational/implementation level assessment on the impact of green practices and green performance

Similar to the assessment conducted in the previous chapter, operational/implementation level assessment involves assessing the relationships between green practices and green performance at the individual item/factor level. It provides an in-depth, firm level, systemic understanding of the one-to-one impact of individual green practices on individual green performance aspects. This understanding is critical because individual green practices could impact each performance differently, and that too could vary across stakeholders. For practitioners, responsible for

implementing green practices (in their relevant department/functions) could use this finding to prioritise implementation of those green practices that yield the highest performance (taking all three performance aspects into consideration).

Similar to the methodology adopted in the operational level assessment in chapter 7, data collected from the focused, in-depth interviews will be used to assess the one to one relationships between green practices and green performance at the firm level. The methodology employed to assess the relationships qualitatively is already discussed in detail in Chapter 3. Table 8.6 shows the one to one relationships between practices and performance.

Table 8.6 Operational/implementation level relationships between green practices and performance

✓✓ Strong Impact ✓ Moderate Impact Blank cell: Low/Negligible Impact

	Core green practices					Facilitating green practices					Green performance
	Green design	Green purchasing	Green transportation	Green construction/manufacturing*	End of life management	EMS and ISO 14001	Environmental training	Environmental auditing	Cross-functional integration	Green-related R&D	
Developer	✓✓	✓				✓✓		✓	✓		Environmental performance
	✓					✓	✓	✓			Economic/cost performance
	✓✓	✓			✓	✓	✓	✓			Organisational performance
Architect/Consultant											
	✓✓					✓✓	✓	✓			Environmental performance
	Not relevant										Economic/cost performance
Main/Sub-Contractor	✓✓				✓	✓✓	✓	✓		✓	Organisational performance
		✓	✓	✓✓	✓	✓	✓	✓	✓		Environmental performance
			✓	✓✓	✓	✓	✓	✓	✓		Economic/cost performance
Supplier	✓	✓	✓✓	✓✓	✓	✓	✓	✓			Organisational performance
	✓✓			✓✓		✓✓	✓	✓	✓	✓	Environmental performance
				✓✓		✓✓		✓			Economic/cost performance
	✓✓			✓✓		✓✓	✓	✓		✓	Organisational performance

*Green construction for Main/Sub-Contractor and green manufacturing for Supplier

The following subsections will discuss in sequence the individual impact of each core and facilitating green practices on each green performance dimension for each stakeholder.

Developer: As seen in Table 8.6, green design, green purchasing, EMS and ISO 14001, environmental training and auditing were found to impact environmental performance. For example, through solar panels installed on the roof, a Developer in one of their projects was able to generate 12% of their electricity requirements. Also, green design was found to impact the economic/cost performance. This was mainly identified with Developers who still had part-ownership in some of their residential projects for managing the common areas. For example, one of the interviewed Developers mentioned that they achieved a 20% reduction in utility bill costs in one of their green buildings (at 85% occupancy level). Also, Developers highlighted that their EMS and ISO 14001, environmental training and auditing activities had helped them to improve their cost/economic performance. A concerted effort in the environmental training and auditing programs to improve the economic/cost aspects of projects was observed in the interviews. Further, respondents acknowledged that practices such as green purchasing, end of life green practices, EMS and ISO 14001, environmental training and auditing activities have helped them improve their brand image, which in turn has improved their organisational performance such as sales and market share.

Architects/Consultants: It was understood from our analysis of the interview data that, in addition to green design, Architects/Consultants facilitating green practices, namely EMS and ISO 14001, environmental training and auditing were also found to improve the environmental performance of the green projects that they have designed and supervised. Several green practices, as shown in Table 8.6, were also found to improve their organisational performance, clearly demonstrating that these practices are important from a business perspective for Architects/Consultants. Since economic/cost performance is not relevant for Architects/Consultants, the relationship between core and facilitating green practices and economic/cost performance is also not relevant.

Contractors: According to the respondents, most of the relevant core and facilitating green practices were found to positively impact all three performance measures. This is promising for

the sector as each practice (except for R&D) was found to impact on one or more aspects of green performance.

Suppliers: While green design and green manufacturing emerged as the two important core green practices impacting the environmental performance, all facilitating green practices were found to impact the environmental performance. As mentioned earlier, one of the glass manufacturers interviewed was able to reduce its energy consumption by 30% and emissions by 60% (as per the respondent from that company) through the mentioned green practices. The same glass manufacturer was also able to develop a technology (through R&D) in which they can provide solar glass surface for buildings in any colour as desired by the Developer instead of supplying the glass in a small number of standard colours and thereby avoiding the need for a trade-off between building aesthetics and environmental performance. Because of the importance given to the aesthetics of the buildings in the UAE construction sector and elsewhere, this innovation was found to significantly improve their sales and market share in the UAE as well as in foreign markets. In addition to R&D, other practices, as shown in Table 8.6, were also found to improve their organisational performance. Finally, with regards to cost/economic performance, from our analysis, only green manufacturing and EMS and ISO 14001 emerged to directly impact economic/cost performance.

8.2.1 Key implications from the operational/implementation level assessment

Some of the important implications evident from the findings in Table 8.6 are as follows:

- Not all green practices impact all performance
- Each green practice impacts each performance differently (high, medium, low/no impact). That is, some green practices provide greater improvement in performance than others.
- The impact of a green practice on the performance is reflective of both the intrinsic effect of that green practice on a green performance as well as the extent, effectiveness, and efficiency of implementation of that practice.
- For any stakeholder, green practices that cause the largest improvement in performance, as well as those practices whose contribution to performance improvement is minimal

could be identified. Managers, depending on their performance focus, can use this information to prioritise implementation of green practice(s) that provide a greater improvement in performance than others. Also, findings can be used to support company decisions to either modify the green practices already in place or to identify new green practices to implement in line with their performance goals/target.

- Some green practices, such as EMS and ISO14001 and environmental auditing, not only improve performance on all three green performance measures, they do so for all the stakeholders. Being able to identify green practices of this kind, which have a sector-wide positive influence on performance, would be of interest to policymakers. It will help them focus their efforts on mechanisms/incentives, which can enhance the implementation of such green practices.
- Firms with resource constraints can use the findings to prioritise the implementation of those green practices first that provide a greater improvement in performance than others.
- The findings also conform to the strategic level assessment that significant win-win opportunities exist in the implementation of green practices.

From a theoretical standpoint, the strength of the impact of core and facilitating green practices on performance can be understood through complexity theory. As evidenced in the study, the improvements in green practices not only depend on the extent of implementation (understood through strategic choice theory, resource and knowledge-based views and resource-dependence theory; already discussed in section 4.3, chapter 4) but also the efficiency and effectiveness of the implementation. For example, in one of the projects of a large Developer, despite the building being LEED pre-gold certified for design, the implementation was a failure to the extent that the performance of the building was worse than that of a normal building. The actual efficiency and effectiveness of implementation of core and facilitating green practices can be explained through the lens of complexity theory (Anderson, 1999).

According to complexity theory, firms operate within a system (in this case a supply chain), and therefore the successful implementation of green practices depends upon how firms manage the complex interactions with the multiple parties involved. As this complexity increases, firms find

it more difficult to implement green practices (Sarkis et al., 2011). For instance, according to one of the respondents, the success of a green project from a Developer's perspective will depend on how well it manages the complex interactions with Architects/Consultants, Contractors and Suppliers (if applicable). In addition, complexity theory can also explain the difficulty in managing the complex systems within the buildings or manufacturing facility. For example, one of the Developers emphasised that the operational performance of one of their buildings was much lower than expected because of the difficulty involved in integrating the different complex systems and optimising their performance. In other words, the complexity of managing the premises post-occupancy increases when the systems used are complex in terms of both operation and compatibility with other systems.

To summarise, this section comprehensively answers the research question (RQ5) proposed in this study. The strategic and operational/implementation level findings on the impact of green practices on green performance are expected to significantly help the efforts of practitioners and policymakers in improving green performance. A comprehensive attempt at this depth and breadth to understand the relationship between green practices and green performance has not been undertaken previously in any sector let alone construction and adds to the novelty of this study.

Chapter 9 - Impact of Facilitating Green Practices on Core Green Practices

In line with research question, RQ6, the objective of this chapter is to understand the impact of facilitating green practices on core green practices. Previous studies have argued that having strong internal green resources and capabilities (facilitating green practices) could lead to the efficient and effective implementation of core green practices (Gonzalez et al., 2008), with some even calling facilitating green practices as necessary precursors for the implementation of core green practices, i.e. implementing facilitating green practices in advance of core green practices (Zhu et al., 2013). Others argue that core green practices should be based on, and require coordination with, facilitating green practices, to be successfully implemented (Walton et al., 1998). For practitioners and policymakers; this understanding (at a strategic level and at operational/implementation level) is important to make informed decisions on the implementation of these green practices.

For instance, at the strategic level, the strong and positive relationship between facilitating and core green practices implies policymakers could consider making facilitating green practices (few or all of them) mandatory for construction firms or could devise support mechanisms for firms to implement facilitating green practices. On the other hand, at the operational/firm level, implementation managers would be interested to know how each facilitating green practice is impacting on each core green practice. This understanding would enable practitioners to prioritise the implementation of those facilitating green practices that have a broad and strong impact on core green practices. Similarly, this understanding would be useful for corporate managers to know whether their investment in developing internal resources and capabilities (facilitating green practices) is helping their external or core green practices. Also, the knowledge of this relationship would enable the respective green practices to be appropriately sequenced.

The following sections will discuss the findings from the strategic and operational/implementation level assessment on the impact of facilitating green practices on core green practices for each stakeholder. Further, relevant management/organisational theories (wherever applicable) will be used to understand the relationships better.

9.1 Strategic level assessment on the impact of facilitating green practices on core green practices

Here, the impact of facilitating green practices on core green practices at the construct level is assessed. This assessment helps us determine the relationship at the sector level. Ideally, facilitating green practices should have a strong impact on core green practices. As explained in the methodology in chapter 3, the structured data collected through the survey will be used to assess the strategic level relationships including testing of the following hypothesis.

H6.1: Facilitating green practices positively impact core green practices.

The validity and reliability of the first-order facilitating green practices construct and second-order core green practices construct were previously established in chapter 3.

9.1.1 Structural equation modelling and hypotheses test results

Similar to the approach used in the previous chapters (chapter 7 and 8), path analysis is used to test the proposed hypotheses. A total of 4 relationships (hypotheses) are assessed in total (one for each stakeholder). The results of path analysis for Developers, Architects/Consultants, Contractors, and Suppliers are given in Table 9.1. The results indicate that all four hypotheses tested are supported. The overall model fit and goodness-of-fit indices obtained during the assessment of path analysis for each stakeholder were well above the acceptable threshold given in Table 3.8 (refer chapter 3). The standardised estimate or the path coefficient represents the strength of the relationships (1 being the highest and 0 being the lowest), i.e. it shows to what degree the extent of implementation of facilitating green practices have contributed to the extent of implementation of core green practices, with 1 being the ideal score.

As seen in the table, 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 a moderate impact for 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.

Table 9.1 Hypotheses test results: Relationships between core and facilitating green practices (All stakeholders) _

	<i>Hypothesized path</i>			Standardized Estimate	Critical Ratio	Significance	Hypothesis supported
H6.1 (Developer)	Facilitating green practices	→	Core green practices	0.76**	2.45	0.017	Yes
H6.1 (Arch/Consult)	Facilitating green practices	→	Core green practices	0.81***	4.26	0.000	Yes
H6.3 (Contractor)	Facilitating green practices	→	Core green practices	0.82***	4.98	0.000	Yes
H6.4 (Supplier)	Facilitating green practices	→	Core green practices	0.30**	2.20	0.029	Yes

***significance at $p < 0.001$; **significance at $p < 0.05$; *significance at $p < 0.1$; ^anon-significant test results

9.2 Operational/implementation level assessment on the impact of facilitating green practices on core green practices

Like previous chapters, operational/implementation level assessment involves assessing the relationships between facilitating green practices and core green practices at the individual item/factor level. Similar to the methodology adopted in the operational level assessment in chapter 7 and 8, the data collected from the focused, in-depth interviews will be used to assess the one to one relationships between facilitating and core green practices at the firm level. The methodology used to qualitatively assess the relationships is already discussed in Chapter 3. Table 9.2 shows the one-to-one relationships between facilitating and core green practices.

Table 9.2 Operational/implementation level relationships between facilitating and core green practices

✓✓ Strong Impact ✓ Moderate Impact Blank cell: Low/Negligible impact

	Facilitating green practices					Core green practices
	EMS and ISO 14001	Environmental training	Environmental auditing	Cross-functional integration	Green-related R&D	
Developer	✓	✓✓	✓✓	✓		Green design
	✓	✓✓	✓			Green purchasing
						Green transportation
						End of life green practices
Architect/Consultant	✓	✓✓	✓✓	✓	✓	Green design
						Green transportation
						End of life green practices
Main/Sub-Contractor	✓	✓	✓	✓		Green purchasing
	✓	✓	✓			Green transportation
	✓	✓	✓	✓		Green construction/manufacturing*
		✓				End of life green practices
Supplier	✓	✓	✓	✓	✓✓	Green design
	✓		✓			Green purchasing
	✓		✓			Green transportation
	✓	✓	✓	✓		Green construction/manufacturing*
						End of life green practices

*Green construction for Main/Sub-Contractor and green manufacturing for Supplier

From the qualitative analysis, it was evident that EMS and ISO 14001 were found to impact some of the core green practices across all stakeholders. As seen in the table, for Developers, they mainly supported green design and green purchasing, as most aspects relating to design and purchasing are integrated into the EMS. Similarly, the green design aspects of Architects/Consultants are also supported by EMS. However, for both Developers and Architects/Consultants, green transportation and end of life green practices were not included in the scope of EMS. For Contractors and Suppliers, EMS and ISO 14001 were found to have a broad impact on all core green practices except the end of life green practices.

Environmental training was found to impact the green design and green purchasing functions of the Developer. It was evident from our interviews that the syllabi or topics for training programs have been mainly focussing on the design and purchasing aspects. When probed, the respondents highlighted that training mainly focussed on regulatory requirements (design based) and the LEED design framework, and occasionally on green purchasing. Aspects related to green transportation and end of life green practices were not included in any of the training materials assessed. For Architects/Consultants, the in-house environmental training programs were found to focus more on design aspects. Also, firms were found to encourage employees to undertake external design-related training/certifications. One of the interviewees (Architect), when probed, mentioned that his training request for 'project management' was declined citing 'not design-related'. For Contractors, the environmental training programs were found to have a broad impact on all core green practices. This is mainly because the Contractors in-house environmental training programs cover employees at all levels and departments including onsite workers. Respondents highlighted that the waste management training programs for onsite (mainly unskilled) workers have helped reduce onsite waste as well as enhance material recovery and recycling in demolition projects. Also, it was encouraging to see green transportation aspects being part of the Contractors training curriculum. For Suppliers, environmental training was found to impact green design and green manufacturing. When probed regarding green purchasing and green transportation, respondents highlighted that the purchasing and transportation practices are standard functions and moreover do not face the challenges that other practices do.

According to Developers, internal and external environmental auditing is the main part of design and purchasing functions. Similar views were echoed by Architects/Consultants on green design. For Contractors and Suppliers, environmental auditing activities were found to impact all core green practices (except for the end of life green practices).

Cross-functional integration of departments was found to impact the green design prospects of Developers and Architects/Consultants and the green purchasing and green construction/green manufacturing prospects of Contractors and Suppliers. Green-related R&D was found to have an impact only on the green design aspects of Architect/Consultants and Suppliers. However, the impact was found to be more for Suppliers than Architects/Consultants. This shows that the effectiveness of R&D programmes is still in their infancy in the UAE.

9.2.1 Key implications from the operational/implementation level assessment

Some of the important implications evident from the findings in Table 9.2 are as follows:

- Not all facilitating green practices impact all core green practices
- Each facilitating green practice impacts each core green practice differently (high, medium, low/no impact). That is, some facilitating green practices provide greater improvement in core green practices than others.
- For any stakeholder, facilitating green practices that cause the broad and/or strongest impact on core green practices can be identified as can those practices whose contribution is narrow and/or low/negligible.
- Managers looking to improve their core green practices (all or select), can use this information to prioritise implementation of facilitating practice(s) that provide a greater improvement in core green practices than others. Also, findings can be used to support company decisions to either modify the facilitating green practices already in place or to implement new facilitating green practices in line with the intended goal of improving core green practices.
- Some facilitating green practices, such as EMS and ISO14001 and environmental auditing, were found to have a broad impact on several core green practices for Contractors and Suppliers. Being able to identify green practices of this kind, which may have a sector-

wide positive impact on core green practices, would be of interest to policymakers. It will help them focus their efforts on mechanisms/incentives, which can enhance the implementation of such facilitating green practices.

From a theoretical perspective, the impact of facilitating green practices on core green practices can be understood through implementation theory (Goggin, 1990). According to implementation theory, the success or failure of new implementation (in this case core green practices) depends on the implementation climate (in this case EMS and ISO 14001), the absorptive capacity of new technology and processes (in this case environmental training, R&D) and organisational readiness (in this case cross-functional integration, environmental auditing). Previously, Pinkse and Dommisse (2009) found that Contractors that actively gather information and build internal technical capacity are keener on adopting green technologies.

To summarise, the relevant one to one relationships between individual facilitating green practices and each core green practices for all stakeholders are understood. The findings (several individual core green practices are well supported by several facilitating green practices) to a good extent conform to the strategic level findings, which indicated a strong correlation between facilitating and core green practices.

Overall, this chapter comprehensively answers the research question (RQ6) proposed in this thesis.

Appendix 9.1 consolidates all the separate (strategic level) findings discussed in chapter 7, 8 and 9 into one comprehensive GSCM framework. Future studies with large sample size can validate the whole framework, though this study has separately validated the different parts of the framework.

Chapter 10 – Impact of firm size and ownership on GSCM

Firm characteristics, namely size and ownership, are widely considered as two important contingency variables in macro-organisational studies that can affect a firm's environmental strategy (Chen and Hambrick, 1995; Zhu et al., 2008b; 2012a, Child and Tsai, 2005; Earnhart et al., 2014). While attempts have been made in other sectors, for the construction sector, the impact of size and ownership on GSCM have not been closely studied or well understood despite its potential impact. This chapter will contribute towards filling this gap in the knowledge in line with the research question, RQ7, and proposed hypotheses in chapter 2.

As stated in chapter 2, this understanding is critical since greening the supply chain would not be effective without the active involvement and participation of all firms regardless of their characteristics. This is even more for an emerging economy such as the UAE, where the construction sector market share is split almost evenly between large firms and SMFs (Oryx, 2013), and has a good share of foreign firms mainly from western countries, such as US and UK with advanced green knowledge, largely due to the open and less burdensome foreign direct investment policy that allows foreign firms to start their subsidiaries or enter partnerships with local firms in the form of joint ventures and mergers. For instance, in 2014, the UAE has witnessed 25% growth in foreign direct investment in the construction sector (TFG, 2015).

The methodology used for understanding the potential influence of firm size and ownership on GSCM is discussed in chapter 3. As mentioned in the methodology, the study will rely mainly on the relatively large scale survey data to determine the underlying size-related and ownership-related differences in GSCM themes/sub-themes (constructs), namely green practices (core and facilitating), green drivers (external and internal), green barriers (external and internal) and green performance (environmental, cost/economic and organisational). However, the empirical insights obtained from the interviews (both phase 1 and 2) will also be used, to the extent possible, to comprehend the 'why' and 'how' aspects of the statistical test results on the underlying size and ownership related differences in GSCM. In sum, using both qualitative and quantitative findings, this chapter will attempt to develop a comprehensive picture of the impact of firm size and ownership on GSCM in the construction sector. Moreover, wherever permissible,

this chapter will attempt to link the findings to the generic literature in other sectors to know whether some of the intrinsic impact of size and ownership on GSCM or related green aspects is the same across all sectors. Finally, the chapter attempts to underpin the findings using established/emerging theories depending on their explanatory and predictive ability to provide a broader, richer and a simplified understanding of the impact of size and ownership on GSCM.

The following sections will address in sequence the main research question, sub-questions and proposed hypotheses. First, this chapter will discuss the impact of firm size on GSCM.

10.1 Assessing the impact of firm size on GSCM themes/sub-themes

The main research question, sub-questions and proposed hypotheses this section will address are given in Table 10.1. As mentioned in chapter 3, the impact of size on GSCM will be understood by assessing the underlying differences in the GSCM aspects among SMFs and large firms. The rationale for grouping small and medium firms is because the green behaviour of these firms is expected to be similar. In fact, this was evident from the interviews. This is also consistent with the findings of previous studies that found size-related differences in GSCM to be less among small and medium firms but more so among SMFs and large firms (Vijayvargy et al., 2017). Further, the survey data across stakeholders will be aggregated, as the overarching objective is to find the impact of firm size on GSCM aspects in the construction sector and less so by stakeholder. In fact, the interviews revealed that impact of size is more intrinsic to the firm than the stakeholder position in the supply chain.

The following sections will address in sequence each research sub-question and hypotheses proposed in the study.

10.1.1 Impact of firm size on green practices' implementation

Firm size could explain why the implementation of green practices is different in different firms. This section will attempt to understand the impact of firm size on green practices by explicitly comparing the 'extent of implementation of green practices' among SMFs and large firms. An independent sample student t-test is performed to statistically test the difference in the mean scores of green practices of SMFs and large firms, and descriptive statistics (Arithmetic mean) is used to assess the magnitude of the differences. Two levels of assessments are carried out,

Table 10.1: Proposed research question, sub-questions and hypotheses on the impact of firm size on GSCM

<i>Main research question: How and to what extent does firm size impact GSCM aspects in the construction sector?</i>		
Sub-question 1 (RQ7.1)	How and to what extent does firm size influence the implementation of core and facilitating green practices in the construction sector?	
Hypotheses	H7.1.1	<i>Core green practices' implementation is greater for large firms than SMFs.</i>
	H7.1.2	<i>Facilitating green practices' implementation is greater for larger firms than SMFs.</i>
Sub-question 2 (RQ7.2)	How and to what extent does firm size influence external green drivers in the construction sector?	
Hypothesis	H7.2.1	<i>Perceived importance/relevance of external drivers are higher for larger firms than SMFs.</i>
Sub-question 3 (RQ7.3)	How and to what extent does firm size influence internal green drivers in the construction sector?	
Hypothesis	H7.3.1	<i>Perceived importance/relevance of internal drivers are higher for larger firms than SMFs.</i>
Sub-question 4 (RQ7.4)	How and to what extent does firm size influence external barriers in the construction sector?	
Hypothesis	H7.4.1	<i>Perceived importance/relevance of external barriers are lower for larger firms than SMFs.</i>
Sub-question 5 (RQ7.5)	How and to what extent does firm size influence external barriers in the construction sector?	
Hypothesis	H7.5.1	<i>Perceived importance/relevance of internal barriers are lower for larger firms than SMFs.</i>
Sub-question 7 (RQ7.6):	How and to what extent is the improvement in green performance (in environmental, cost/economic and organisational terms) influenced by firm size?	
Hypotheses	H7.6.1	<i>The improvement in environmental performance is higher for large firms than SMFs.</i>
	H7.6.2	<i>The improvement in cost/economic performance is higher for large firms than SMFs.</i>
	H7.6.3	<i>The improvement in organisational performance is higher for large firms than SMFs.</i>

strategic level and operational/implementation level. At the strategic level, the differences in green practices among SMFs and large firms are understood at the construct level, whereas at the operational/implementation level, the differences in green practices are understood at item/factor level. Relevant management theories are also used to underpin the findings.

These theories enable understanding at both levels and are important to determine whether resources and capabilities associated with SMFs and large firms play a role in the implementation of green practices. Determining whether SMFs are implementing greater, lesser or equal levels of green practices compared to large firms has important strategy and policy implications. It can help practitioners, supply chain stakeholders, investors, non-government organisations and government policymakers to either develop support mechanisms/frameworks to aid smaller or larger organisations or across all supply chain stakeholders and/or develop pressure mechanisms (such as through more stringent or targeted regulations) to promote sector-wide implementation of green practices.

The underlying differences in green practices between SMFs and large firms at the construct level are examined by performing a t-test on the aggregated confirmatory factor analysis (CFA) factor scores obtained from each stakeholder. CFA factor scores are used because they can more accurately capture the construct than using a construct mean (average of mean values of individual items in the construct) (DiStefano et al., 2009). On the other hand, the underlying differences in green practices between SMFs and large firms at the sub-construct or factor/item level are understood by performing a t-test on the aggregated mean scores obtained from each stakeholder. The results of the t-test at the construct level and item/factor level for core and facilitating green practices are given separately in Table 10.2 and 10.3 in line with the proposed hypotheses H7.1.1 and H7.1.2.

10.1.1.1 Impact of firm size on core green practices' implementation

Table 10.2 shows the underlying differences at the construct and item/factor level for core green practices. While core green practices as such are relevant to all stakeholders, as discussed in chapter 5, some of their underlying items/factors may not be relevant for all stakeholders. For example, as previously stated, green design is only relevant for Architects/Consultants, and

Suppliers, as Contractors are rarely involved in the design. Similarly, for green construction/green manufacturing, the relevant stakeholders will be Contractors and Suppliers respectively, as Developers and Architects/Consultants are not involved in any construction/manufacturing activities. This implies that for each individual item/factor, the aggregate data comes from the relevant stakeholders. The mean differences (MD) show the actual differences in the mean values among SMFs and large firms, while the t-value and significance (p-value) shows whether the differences are significant or not.

The results from the table show that the hypothesis (H7.1.1) is supported, both at the construct level and at the item/factor level. At a generic level, this supports the literature's 'skewness' towards large firms implementing more green practices than SMFs.

As seen from the table, at the construct level, the significant mean difference (MD=-0.4, $p < 0.001$) implies that SMFs are lagging behind large firms in the extent of implementation, though their implementation is still moderate as seen from the mean value (M=3.5).

At the item/factor level, the results show that the differences are significant and consistent across all practices with mean difference ranging from -0.4 for green design and green transportation to -0.5 for green purchasing, green construction/manufacturing and end of life green practices.

The differences in the core green practices implementation were not surprising as it was evidenced from the interviews that implementing green practices is a very resource and knowledge intensive task for all stakeholders and that large firms definitely hold the edge over SMFs. For example, green building design requires technical and managerial know how on the various green systems and its implications on green performance. As evidenced from the interviews, many SMFs do not have the technical and managerial knowledge of the latest green design practices. Similarly, for green purchasing (which involves considering environmental aspects in every contract, which could be hundred if not thousand in a typical construction project), it was evidenced from the interviews that SMFs compared to large firms suffer from lack of skilled human resources to carry out tasks such as green purchasing which most SMFs consider

Table 10.2: Differences in the extent of implementation of core green practices among SMFs and large firms

Construct	Relevant Stakeholders	Mean (SMF)	Mean (Large)	Mean Difference	t-value	Significance	Responses (SMF)	Responses (Large)	Hypothesis supported
All Core green practices (combined)	Developer, Architect/ Consultant, Contractor, Supplier	3.5	3.9	-0.4	-4.27	0.000***	216	239	Yes
Individual - core green practices									
Green design	Developer, Architect/ Consultant, Contractor, Supplier	3.8	4.2	-0.4	-2.71	0.007**	111	131	Yes
Green purchasing	Developer, Contractor, Supplier	3.5	4.0	-0.5	-4.53	0.000***	169	179	Yes
Green transportation	Developer, Architect/ Consultant, Contractor, Supplier	3.3	3.7	-0.4	-3.00	0.003**	216	239	Yes
Green Construction/Manufacturing	Contractor, Supplier	3.8	4.3	-0.5	-3.47	0.000**	139	151	Yes
End of life green practices	Developer, Architect/ Consultant, Contractor	3.2	3.7	-0.5	-3.25	0.001**	182	196	Yes

Scale: 1(very low extent) - 5 (very high extent); ***significance at $p < 0.001$; **significance at $p < 0.05$; *significance at $p < 0.1$

Table 10.3: Differences in the extent of implementation of facilitating green practices among SMFs and large firms

Construct	Relevant Stakeholders	Mean (SMF)	Mean (Large)	Mean Difference	t-value	Significance	Responses (SMF)	Responses (Large)	Hypothesis supported
All facilitating green practices (combined)		3.5	3.9	-0.4	-4.98	0.000***	216	239	Yes
Individual – core green practices									
EMS and ISO 14001	Developer, Architect/ Consultant, Contractor, Supplier	3.9	4.3	-0.4	-5.55	0.000***	216	239	Yes
Environmental training		3.8	4.2	-0.4	-5.08	0.000***	216	239	Yes
Environmental auditing		3.4	3.9	-0.5	-5.83	0.000***	216	239	Yes
Cross functional integration		3.8	3.9	-0.1	-1.06	0.290	216	239	No
Green-related R&D		2.7	3.3	-0.6	-10.3	0.000***	216	239	Yes

Scale: 1(very low extent) - 5 (very high extent); ***significance at $p < 0.001$; **significance at $p < 0.05$; *significance at $p < 0.1$

to be outside their core business activities. Large firms, on the other hand, because of their skilled human resources, were found to carry out more stringent green purchasing activities than SMFs. Also, the strong financial resources of large firms could be reasoned for some of their green practices implementation. For instance, green projects require considerable capital investment up front, specifically to implement systems such as solar water heaters, energy efficient HVACs, building management systems and so on, and could explain why large Developer firms are keener on green building projects than SMFs. Similarly, Contractors and Suppliers, because of their financial resources, were found to invest in innovative machinery, equipment and automation technologies to minimise the adverse environmental implications during the construction/manufacturing process. SMFs, on the other hand, were found to have fewer financial resources to invest in green equipments and technologies.

While there is not much construction sector literature to compare our findings with, they do echo the findings of Qi et al. (2010), who found large Contractors are statistically more inclined to implement green construction practices than small Contractors because they have more resources (both financial and human resources) to implement green practices. From a generic perspective, the findings do compare well with previous findings in other sectors such as Vijayvargy et al. (2017) and Zhu et al. (2008) who found small-scale organisations show lower levels of GSCM implementations including green design and green purchasing practices, with one of the plausible reasons highlighted by both studies being lack of adequate resources.

10.1.1.2 Impact of firm size on facilitating green practices implementation

Table 10.3 shows the underlying differences in the extent of implementation at the construct and item/factor level for facilitating green practices. The results from the table show that the hypothesis (H7.1.2) is supported at the construct level. The mean difference (MD=-0.4, $p < 0.001$) is significant and comparable to that of the difference seen in core green practices (MD=-0.4, $p < 0.001$), thereby supporting the findings in the literature that large firms implement more green practices than SMFs (Arora and Cason, 1996; King and Lenox, 2001).

Also, at the item/factor level, the hypothesis is supported except for cross-functional integration where no significant differences were found in the surveys (MD=-0.1, $p = 0.290$). For cross-

functional integration, our understanding from the interviews is that the relatively smaller size and less bureaucratic structure found among SMFs may have helped them in their cross-functional integration to be at par with large firms. However, for all other items/factors, the mean difference shows consistent and significant difference, with difference ranging from -0.4 for environmental training to -0.7 for green-related research and development (R&D).

The results are not surprising, as it was evidenced from the interviews that facilitating practices, in general, were lower among SMFs than large firms across all stakeholders. For example, the rigour in green-related R&D for developing innovative products was found to be higher among large firms than SMFs. The underlying reason again is that large firms were more capable financially in allocating dedicated R&D budget, whereas, in most SMFs, no dedicated budget was found for green R&D. This could well be because cash flow, in general, was observed to be a concern for SMFs. Similarly, the underlying difference in environmental training (MD=-0.5) between large firms and SMFs (in general across stakeholders) were also not surprising, as it was evidenced from the interviews that large firms conduct both in-house training and external training, whereas the training programs of SMFs were mainly limited to their own employees. Also, the rigour of the training programs conducted was also found to be different, with large firms conducting more frequent and diverse training programs than SMFs. Further, employees in large firms were also found to have more opportunities to take certification programs than SMFs. This echoes the findings of Aragón-Correa (1998), who found environmental training programs of large firms to be higher than that of small firms in Spain. This was mostly because large firms were found to have the in-house expertise such as dedicated training departments and/or training managers as well as the dedicated training budget to carry out training activities and/or fund employees to get outside training/certifications. On the other hand, SMFs, because of their limited budget and in-house expertise, were found to limit themselves to selective and short training programs and only for select employees. Also, external training/certification opportunities for employees in SMFs were observed to be very competitive compared to large firms.

For environmental auditing, too, the shortage of resources, lack of technical expertise and fewer financial resources observed for SMFs could explain the underlying difference (MD=-0.5), i.e. the

environmental auditing practices of SMFs being less than that of large firms. Like environmental training, large firms were found to conduct both in-house and external audits of Contractor and Suppliers, where SMFs auditing was mainly limited to in-house auditing, and that too was mostly limited to design related aspects. Also, the frequency of the environmental auditing was found to be much higher for large firms than SMFs and is usually more rigorous in large firms (conducted by reputed external auditors) compared to SMFs which is mostly conducted internally.

Also, as understood from the interviews, the higher implementation of EMS and ISO 14001 among large firms than SMFs (MD=-0.4) could be because these implementation and certification costs as a percentage of the revenue for large firms is relatively less compared to SMFs, who consequently were found to struggle with the cost associated with EMS and ISO 14001. This finding is consistent with several studies in the literature that found larger facilities are more likely to obtain ISO 14001 certifications because of their greater resources (Tambunlertchai et al. 2013; Chan and Li 2001; Blackman and Guerrero 2012; Dasgupta et al., 2000).

Overall, the survey findings show that green practices, both core and facilitating, are higher for large firms than SMFs, in line with the overwhelming evidence in the generic literature showing that larger firms implement greater green practices than SMFs (Zhu et al., 2008; Ben Brik et al., 2013; Mohanty and Prakash, 2014; Vijayvargy et al., 2017).

To summarise, the following key aspects, as discussed above, could be reasoned for the underlying differences observed in the country-wide survey:

- Larger firms because of their vast resources have more flexibility in terms of allocating/ reallocating resources across projects and maintain specialised team than SMFs to implement various green practices. SMFs on the other hand lack the information, resources, and expertise to implement green practices.
- Large firms have more strategic choices to implement green practices than SMFs because of their resources. SMFs, because of their resource limitations (both financial and human resources), had to be content with implementing a small number of select green practices.

- SMFs have little technical and managerial know-how in implementing green practices. Large firms, even if they did not have the expertise internally, because of their financial resources, were observed to implement green practices by relying largely on the resources of supply chain partners. For example, a large Developer interviewed was found to give the entire design and build responsibility to the Architect/Consultant.

This finding contradicts those few studies in the literature that put forward the notion that large firm demonstrate organisational inertia to change business practices (Miller and Chen, 1994) and that firm's ability to implement new environmental technologies reduces as their size increases (Hannan and Freeman, 1989).

From a theoretical standpoint, this can be explained from a resource and knowledge based view. Also, to complement the resource and knowledge based view, the strategic choice theory can be used to explain the strategic choices of both large firms and SMFs; and resource dependence theory could explain the green practices implementation of large firms even when they did not have the expertise internally to implement green practices.

Overall, the findings have several implications for practitioners and policymakers. Some of the implications are as follows:

- The cumulative effects of low extent of implementation of a large number of SMFs can be a source of environmental risk and a bottleneck in pursuing the goal of a greener supply chain.
- Policymakers, industry leaders and NGOs, though not very much active in the UAE, need to coherently work towards improving the green practices of SMFs.
- Concerned authorities could create a diffusion mechanism (flow of green-related knowledge, skills and expertise from large firms to SMFs) to improve the green practices of SMFs such as through collaborative partnerships and mentoring opportunities with large firms and/or through large firms pressurising SMFs to implement green practices. The underlying basis is the diffusion of innovation theory (Rogers, 1962). According to the theory, diffusion of an innovation, in our case managerial and technical know-how to implement green practices, can be viewed as a process of initiation, persuasion, planning,

adoption and confirmation (Sarkis et al., 2011). Diffusion happens naturally if it is communicated through particular channels, such as through government policies, tender specifications or purchase contracts, over time, among the members of a social system.

Next, the impact of firm size on the perceived importance/relevance of green drivers are discussed.

10.1.2 Impact of firm size on green drivers

As seen in chapter 5, green practices in a firm are influenced by several green drivers. However, the perceived importance/relevance of these drivers facing firms, as well as the heterogeneity in firms' responsiveness to these drivers, could vary depending on the size of the organisation (Baylis et al., 1998). This section will attempt to understand the impact of firm size on the perceived importance/relevance of green drivers among SMFs and large firms. Again, an independent sample student t-test is performed to statistically test the difference in the mean values of green drivers (perceived importance/relevance) of SMFs and large firms at the strategic/construct level (external drivers and internal drivers), whereas at the operational/implementation level, the differences in green drivers are understood at item/factor level. Relevant management/organisational theories are also used to underpin the findings.

These theories enable understanding at both levels and are important to determine whether firm size plays any role in the perceived importance/relevance of these drivers. Determining whether large firms are perceiving more, less or the same extent of pressures or motives compared to SMFs is important to enact policies and support mechanisms to ensure all firms, regardless of their size have similar drive in implementing green practices. The following sections discuss the underlying differences in external and internal green drivers perceived among SMFs and large firms.

10.1.2.1 Impact of firm size on external green drivers

The results of the t-test showing the underlying differences in the perceived importance/relevance of external green drivers among SMFs and large firms is given in Table 10.4. The results show that the proposed hypothesis (H7.2.1), i.e. the perceived importance/relevance of external drivers will be higher for large firms compared to SMFs, is not supported at the

construct level. In fact, the results at the construct level were found to be significant the other way around, i.e. the perceived importance/relevance of external pressure being higher and more significant for SMFs than large firms (MD=0.3, $p<0.05$). This contradicts the findings and propositions in the literature that suggest larger firms receive more pressure from their social and economic environment (González-Benito and González-Benito, 2006) and that SMFs receive less pressure (Grant et al., 2002; Zhang et al., 2008).

Also, at the individual level, except consumer pressure (relevant only for Developer), none of the individual external pressures were found to be significantly high for large firms vis-à-vis SMFs. Moreover, two of the external pressures, namely green-related government regulation (MD=0.6, $p<0.001$) and stakeholder pressure (MD=0.4, $p<0.001$) were found to be high and more significant for SMFs than large firms. This is in stark contrast to the previous findings in the literature, such as Baylis et al. (1998) who found large firms face heightened regulatory and stakeholder pressure, and Grant et al. (2002) who observed that smaller firms receive special treatment and exemptions from environmental regulations and taxes.

While it seems to contradict the literature findings, reasonable evidence was found during the interviews that large firms perceive external pressure less than SMFs. For example, with regards to green-related government regulation, it was evident from the additional interviews conducted with the regulators that they do not differentiate or target firms in the UAE construction sector based on size. While all firms face the same regulatory pressure, as evidenced from the interviews, the relatively low relevance/importance to regulatory pressure perceived by large firms is because they consider it less onerous to fulfil compared to SMFs who consider meeting green-regulations as a cumbersome task and therefore consider it very seriously. Also, small firms acknowledged that any regulatory fines or penalties could have significant adverse effects on their operations.

Like regulatory pressure, it was observed from the interviews that the relevance/importance of stakeholder pressure is less for large firms than SMFs because large firms consider it less onerous to fulfil and/or they consider themselves (given their large size) in a decent position to negotiate and thwart any unrealistic/unwanted pressure they receive from stakeholders. On the contrary,

Table 10.4 Differences in perceived importance/relevance of external green drivers among SMFs and large firms

Construct	Relevant Stakeholders	Mean (SMF)	Mean (Large)	Mean Difference	t-value	Significance	Responses (SMF)	Responses (Large)	Hypothesis supported
All External Drivers (combined)	Developer, Architect/Consultant, Contractor, Supplier	3.3	3.0	0.3	3.34	0.001**	216	239	No
Individual - external green drivers									
Government green-related regulations	Developer, Architect/Consultant, Contractor	3.5	2.9	0.6	7.81	0.000***	182	196	No
Pressure from supply chain stakeholders	Developer, Architect/Consultant, Contractor, Supplier	3.3	2.9	0.4	4.08	0.000***	216	239	No
Pressure from competitors	Developer, Architect/Consultant, Contractor, Supplier	3.0	2.9	0.1	1.62	0.106	216	239	No
Pressure from end-consumers	Developer	1.6	2.3	-0.7	-4.00	0.000***	32	28	Yes

Scale: 1(very low relevance/importance) - 5 (very high relevance/importance); ***significance at $p < 0.001$; **significance at $p < 0.05$; *significance at $p < 0.1$

Table 10.5 Differences in perceived importance/relevance of internal green drivers among SMFs and large firms

Construct	Relevant Stakeholders	Mean (SMF)	Mean (Large)	Mean Difference	t-value	Significance	Responses (SMF)	Responses (Large)	Hypothesis supported
All Internal Drivers (combined)	Developer, Architect/Consultant, Contractor, Supplier	3.2	3.9	-0.7	-7.95	0.000***	216	239	Yes
Individual - internal green drivers									
Environmental Commitment	Developer, Architect/Consultant, Contractor, Supplier	3.3	3.9	-0.6	-7.49	0.000***	216	239	Yes
Reduce costs	Developer, Contractor, Supplier	2.9	3.8	-0.9	-9.29	0.000***	169	179	Yes
Enhance reputation/brand image	Developer, Architect/Consultant, Contractor, Supplier	3.3	3.9	-0.6	-6.41	0.000***	216	239	Yes
Enter foreign markets	Developer, Architect/Consultant, Contractor, Supplier	3.0	3.9	-0.9	11.9	0.000***	216	239	Yes

Scale: 1(very low relevance/importance) - 5 (very high relevance/importance); ***significance at $p < 0.001$; **significance at $p < 0.05$; *significance at $p < 0.1$

interviewed SMFs consider stakeholder pressure seriously, as they run the risk of going out of business or being blacklisted if they do not comply with stakeholder requirements. This is mostly because SMFs in the UAE construction sector were found to rely on a few large supply chain partners for the majority of their business and therefore would seek to comply with the green requirements of their larger partners to secure continuous business.

While no differences were found for competitor pressure among SMFs and large firms in the surveys and the interviews, one small support was found for the proposed hypothesis (H7.2.1) in the form of consumer or end-customer pressure, which is relevant only for Developers. Despite being low overall, consumer pressure was found to be relatively higher for large firms than SMFs (MD=-0.7, $p < 0.001$). During interviews, large Developers highlighted that their large projects attract foreign buyers and investors, who look for green related aspects in the project. On the other hand, SMFs in the UAE was found to focus more on local buyers, who, as mentioned earlier, are less aware of the benefits of green buildings.

10.1.2.2 Impact of firm size on internal green drivers

The t-test results on the underlying differences in the perceived importance/relevance of internal green drivers among SMFs and large firms are given in Table 10.5. The results show that the hypothesis (H7.3.1) is supported, both at the construct level and at the item/factor level. The results do conform to some of the previous findings in the generic and construction literature that large firms are more internally driven towards environmental initiatives than SMFs (Baylis et al., 1998; Abidin, 2010).

At the construct level, as seen in the table, the mean difference is considerable and significant (MD=-0.7, $p < 0.001$). In fact, at the item level too, the results show the consistent and significant difference in each of the internal drivers assessed among SMFs and large firms. As seen in the table, these mean differences ranged from -0.6 for environmental commitment and improve brand image/reputation to -0.9 for reduce costs and enter foreign markets, all significant individually at $p < 0.001$.

With regard to environmental commitment of firms as a driver for green practices, the results are in accordance with Baylis et al. (1998), who found large firms to be more environmentally

committed than SMFs concerning both corporate environmental policies and employee concerns. This is also consistent with the previous findings of Abidin (2010), who reported higher environmental commitment by large Malaysian Developers than small and medium Developers. On the other hand, there is little evidence to support the notion that small business is environmentally responsible by nature (Besser, 1999; BITC, 2002; EMSF, 2004) and/or have environmentally responsible ownership (Solymossy and Masters, 2002; Teal and Carroll, 1999).

Similarly, cost reduction as a driver of green practices was perceived more by large firms than SMFs, especially among large Contractors and Suppliers. For example, large Contractors stressed the significant cost reduction potential in projects from implementing green construction practices. This echoes the previous findings of Baylis et al. (1998), who found cost reduction as a bigger driver for large firms than SMFs, with one of the plausible reasons being the significant cost reduction opportunities and consequent increase in profits. On the other hand, as evidenced from the interviews, SMFs are either unaware of the cost reduction potential or see less opportunity in cost reduction in projects because they tend to limit themselves to small and medium projects, where the cost reduction potential is relatively less compared to large projects.

As evidenced from the interviews, the perceived difference among firms with regards to 'enter foreign market' as a driver of green practices was because large firms across all stakeholders are keen on entering foreign markets including US and UK, where the regulatory and stakeholder requirements require firms to implement more stringent green practices than those experienced in the UAE. On the other hand, interviewed SMFs were found to focus more on the local UAE market. For example, all large Suppliers interviewed have considerable exports to foreign countries. Similarly, some of the large Architects/Consultants interviewed were seen to use UAE as a base (as well prestigious green projects in the UAE as reference) to expand to other foreign countries.

To summarise the impact of firm size on green drivers, some of the key findings and implications for practitioners are as follows:

- Different firms perceive the same pressures differently. For example, large firms consider the same regulatory pressure to be less relevant/important than SMFs.

- Policymakers should consider the potential implications of policy/regulatory changes on SMFs before enacting them. As evidenced from the study, SMFs are struggling to meet the regulatory requirements.
- Policymakers may decide on more stringent green regulations specific for large firms, since they consider the current regulations less onerous to fulfil.
- Governments and industry leaders could try to increase the awareness levels of buyers/customers in the UAE, so that could impart healthy pressure on SMFs to implement green practices by demanding/showing preference to green projects.
- The commitment to protect the environment is relatively less among SMFs than large firms. Given the sheer number of SMFs, this is a concern in pursuing the goal of a greener supply chain.
- Governments and industry leaders could try to increase the awareness levels of SMFs on the potential benefits of implementing green practices.
- Any government incentive/subsidy programs, as seen in other sectors for SMFs (which are not available in the UAE), could support/motivate SMFs to implement green practices.
- Preferential treatment for SMFs in government projects, and green awards and recognitions for SMFs, as seen in other sectors, could motivate SMFs to implement green practices.

Overall, the results show that the perceived importance/relevance of external drivers are high for SMFs in contrast to the findings in the literature, whereas internal drivers overall are higher for large firms than SMFs in line with the findings in the literature. From an institutional theoretical perspective, this results shows that SMFs are reactive in nature driven by coercive, normative and mimetic pressures, whereas large firms are more proactive due to their high cognitive isomorphism (socio-cultural responsibility) and/or due to the high awareness of the strategic choice benefits associated with green practices such as reputation/brand image, cost reduction and foreign market share.

Next, the impact of firm size on the relevance/importance of green barriers are discussed.

10.1.3 Impact of firm size on green barriers

Chapter 5 discussed several barriers (external and internal) facing stakeholders in the UAE construction sector. Similar to drivers, the perceived importance/relevance of these barriers facing firms, as well as the heterogeneity in firms' responsiveness to these barriers, could vary depending on the size of the firm. This section will attempt to understand the impact of firm size on the perceived importance/relevance of green barriers among SMFs and large firms by performing t-test at both strategic and operational/implementation level. Here also, wherever relevant, management/organisational theories are used to discuss the findings. This theory enables understanding at both levels and is important to examine whether size plays any role in the firm's ability to overcome/manage the barriers. Also, knowing the perceived barriers facing SMFs are more, less or the same extent compared to large firms is important to enact policies and support mechanisms to ensure all firms develop the capability to minimise/eliminate the impact of these barriers and/or that these barriers are minimised/eliminated at the source (in the case of external barriers).

The following sections discuss the underlying differences in external and internal green barriers among SMFs and large firms.

10.1.3.1 Impact of firm size on external barriers

The results of the t-test conducted to understand the underlying differences in the perceived importance/relevance of external green barriers among SMFs and large firms is given in Table 10.6. The results show that the external barriers are less of concerning to large firms than SMFs, thereby supporting the proposed hypothesis (H7.4.1), both at the construct level and at each of the item/factor level.

At the construct level, the mean difference is considerable and significant (MD= 0.6, $p < 0.001$). Additionally, at the item level, the results show the consistent and significant difference in each of the external barriers assessed among SMFs and large firms. As seen in the table, these mean differences ranged from 0.5 to 0.6, all significant individually at $p < 0.001$.

Although there is no direct available reference in relation to the findings in the literature, as evidenced from the interviews, it could be argued that large firms, because of their superior

Table 10.6 Differences in perceived importance/relevance of external barriers among SMFs and large firms

Construct	Relevant Stakeholders	Mean (SMF)	Mean (Large)	Mean Difference	t-value	Significance	Responses (SMF)	Responses (Large)	Hypothesis supported
All External Barriers (combined)	Developer, Architect/ Consultant, Contractor, Supplier	3.6	3.0	0.6	5.82	0.000***	216	239	Yes
Individual –external barriers						0.000***			Yes
Shortage of green professionals		3.4	2.8	0.6	6.38	0.000***	216	239	Yes
Shortage of green suppliers		3.6	3.0	0.6	6.27	0.000***	216	239	Yes
Tight and inflexible stakeholder deadlines		3.7	3.2	0.5	4.89	0.000***	216	239	Yes
Lack of stakeholder collaboration		3.5	3.0	0.5	5.11	0.000***	216	239	Yes

Scale: 1(very low relevance/importance) -5 (very high relevance/importance); ***significance at $p < 0.001$

Table 10.7 Differences in perceived importance/relevance of internal barriers among SMFs and large firms

Construct	Relevant Stakeholders	Mean (SMF)	Mean (Large)	Mean Difference	t-value	Significance	Responses (SMF)	Responses (Large)	Hypothesis supported
All Internal Barriers (combined)	Developer, Architect/ Consultant, Contractor, Supplier	3.9	3.2	0.7	6.81	0.000***	216	239	Yes
Individual – internal barriers									
High cost of implementation		4.1	3.4	0.7	6.60	0.000***	216	239	Yes
Lack of knowledge and awareness of green practices		3.6	2.9	0.7	7.02	0.000***	216	239	Yes

Scale: 1(very low relevance/importance) -5 (very high relevance/importance); ***significance at $p < 0.001$

resources and capabilities are in a much better position than SMFs to manage these externalities. For instance, in the case of shortage of green professionals as a barrier, it was evident during the interviews that large firms view this as a less of a barrier (because they have the financial resources), as they were found to offer attractive packages to hire certified green professionals from countries such as the UK, US and Germany as well as certify their own employees. Similarly, with regards to shortage of green suppliers as a barrier, large firms consider it to be less of a barrier than SMFs because they are in a better position (because of their size) to negotiate favourable terms with overseas foreign Suppliers than SMFs. Also, the high cost of implementation was perceived as less of a barrier by large firms because the green investments as a proportion of their annual turnover are smaller compared to SMFs. Also, tight and inflexible deadlines were found to be less of a barrier for large firms on two accounts. First, they have more resources than SMFs to arrange or reallocate resources across projects to ensure the project deadlines are met. Secondly, because of their size, they are in a much better position to negotiate the deadline with the Client than SMFs. For example, one of the large Aluminium manufacturers interviewed, who has over 25% market share in the region, highlighted that neither their quality nor green initiatives of their products are compromised because of their tight and inflexible stakeholder deadlines. Finally, as regards stakeholder collaboration, although in general it was observed from the interviews that most stakeholder relationships are one-off in nature until project completion, larger firms were found to associate with each other in more than one project. Moreover, it was observed during interviews that the trust in general for stakeholders to share information with larger firms was higher than SMFs, with one of the reasons highlighted being that larger firms have a more stringent confidentiality policy than SMFs.

Overall, the underlying differences in the external barriers from a theoretical perspective can be explained from a resource and knowledge based view. As evidenced from the interviews, large firms, because of their vast resources and knowledge, are able to better manage these barriers than SMFs.

10.1.3.2 Impact of firm size on internal barriers

The results of the t-test conducted to understand the underlying differences in the perceived importance/relevance of internal green barriers among SMFs and large firms are given in Table 10.6.

Like external barriers, the results show that the internal barriers are less of concern for large firms than SMFs, thereby supporting our proposed hypothesis (H7.5.1), both at the construct level and at each of the item/factor level.

At the construct level, the mean difference is considerable and significant (MD= 0.7, $p < 0.001$). Also, the results at the item/factor level show that the differences are also consistent and significant across the two internal barriers assessed, namely the high cost of implementation (MD=0.7, $p < 0.001$) and lack of knowledge and awareness (MD=0.7, $p < 0.001$). The findings support the overwhelming evidence in the literature that shows SMFs face much greater internal barriers than large firms (Biondi et al. 2000, de Bruijn and Hofman 2000, Friedman et al. 2000, Kassinis 2001, Friedman and Miles 2002). These differences in internal barriers were also observed during the interviews.

Overall, with regard to green barriers in general, it could be generalised that SMFs suffer from lack of information, resources (both financial and human), and technical and managerial know how. From a theoretical standpoint, the overwhelming evidence again points to a resource and knowledge based view of the firm. Policymakers and large firms need to formulate programs to support SMFs.

To summarise the impact of firm size on external and internal green barriers, some of the key findings and implications for practitioners are as follows:

- Large and SMFs perceive the same barriers differently. For example, large firms consider the lack of local green suppliers (which is the same for all firms) to be less of a barrier than SMF because of their ability to manage the barriers.
- The sector, in general, will benefit if some form of support mechanisms is provided to SMFs to manage these barriers.

- Governments and industry leaders must attempt to eliminate/minimise the external barriers at the source. For example, attracting more foreign green suppliers to start operations in the UAE, or encouraging local suppliers to develop green products, could minimise the challenges relating to lack of local green suppliers. Similarly, any efforts to regulate the price of green products will be encouraging for the sector so that they become affordable for all firms.
- Before enacting any green regulations, the government should take into consideration the constraints facing SMFs, as they may not keep up with the regulations and may lead them to go out of business.

Next, the underlying differences in the green performance (environmental, cost/economic and organisational) between SMFs and large firms are examined.

10.1.4 Impact of firm size on green performance

The impact of firm size on green performance across all three dimensions is understood by performing a t-test on the extent of improvement of environmental, cost/economic and organisational performance separately for SMFs and large firms. Again, two levels of assessments are carried out, strategic level and operational/implementation level.

The following sections discuss separately the underlying differences in environmental, cost/economic and organisational performance among SMFs and large firms.

10.1.4.1 Impact of firm size on environmental performance

The t-test results on the differences in the extent of improvement of environmental performance among SMFs and large firms are given in Table 10.8. The results at the construct level show that the differences in the extent of improvement in environmental performance are significant, with larger firms demonstrating higher performance than SMFs (MD=-0.3, $p < 0.05$). This supports the proposed hypothesis (H7.6.1) in the study. As seen in section 10.1.1.1 and 10.1.1.2, the high extent of implementation of green practices in large firms vis-à-vis SMFs could be reasoned for the relatively higher environmental performance of large firms. Further, as evidenced from the interviews, the relatively high efficiency and effectiveness of green practices implementation of large firms could have also contributed to the relatively higher environmental performance of

Table 10.8 Differences in the extent of improvement of environmental performance among SMFs and large firms

Construct	Included Stakeholders	Mean (SMF)	Mean (Large)	Mean Difference	t-value	Significance	Responses (SMF)	Responses (Large)	Hypothesis supported
All Environmental Performance (combined)	Developer, Architect/ Consultant, Contractor, Supplier	3.5	3.8	-0.3	-3.33	0.001**	216	239	Yes
Individual – environmental performance									
Reduction in environmental accidents		3.7	3.9	-0.2	-1.52	0.129	216	239	No
Reduction in greenhouse gas emissions have decreased		3.4	3.8	-0.4	-4.07	0.000***	216	239	Yes
Reduction in water consumption		3.5	3.9	-0.4	-4.24	0.000***	216	239	Yes
Reduction in energy consumption		3.6	3.9	-0.3	-3.84	0.000***	216	239	Yes
Reduction in landfill waste		3.4	3.8	-0.4	-3.76	0.000***	216	239	Yes
Reduction in material use		3.2	3.7	-0.5	-6.23	0.000***	216	239	Yes
Reduction in use of hazardous materials		3.8	4.0	-0.2	-1.60	0.109	216	239	No

Scale: 1 (very low improvement) -5 (very high improvement); ***significance at $p<0.001$; **significance at $p<0.05$

large firms than SMFs. The findings to some extent confirm the results of Vijayvargy et al. (2017) and Gonzalez et al. (2008) who found the environmental performance of large firms to be significantly higher than that of small firms. Certainly, it rejects the notion that adverse environmental implications of large firms are higher than SMFs (Grant et al., 2002).

At the individual item/performance measure, not surprisingly 5 out of 7 measures were assessed to be significantly higher for large firms with mean difference ranging from -0.3 for reduction in energy consumption to -0.5 for reduction in material use. The two measures for which the difference emerged to be insignificant are reduction in environmental accidents and reduction in hazardous material use. The insignificant difference between these two measures could be because, as evidenced from the interviews, most of the SMFs and large firms have strict 'zero accidents' policies and 'hazardous materials usage' policies as part of their stringent health and safety regulations, and most firms, especially SMFs, consider environmental accidents and hazardous materials as an extension of the health and safety regulations.

For others, in addition to the extensive, efficient and effective implementation of green practices, as evidenced by the interviews, the other potential reasons for the high performance of large firms vis-à-vis SMFs is because they tend to more closely monitor and report environmental performance and hence they are in a much better position to make corrective actions to improve performance. Furthermore, the environmental performance disclosure requirements of foreign countries that these large firms tend to target were found to be high. However, despite these aspects, such as green practices implementation, monitoring and reporting performance being lower for SMFs, it is important to note that SMFs are still performing moderately well (M=3.5) and their performance is not that far behind large firms (M=3.8).

From a theoretical perspective, this can be explained from the premise of legitimacy theory. As mentioned before, legitimacy is a generalised perception or assumption that the actions of an entity are desirable, proper or appropriate within some socially constructed system of norms, values, beliefs and definitions. It was observed that larger firms are making a concerted effort to increase their legitimacy (by means of improving environmental performance) among governments, supply chain partners and with foreign markets.

10.1.4.2 Impact of firm size on economic/cost performance

The t-test results on the differences in the extent of improvement of economic/cost performance among SMFs and large firms are given in Table 10.9. The results at both the construct level and at the individual item/performance measure show that the differences in the extent of improvement in economic/cost performance are significant, with larger firms demonstrating higher performance than SMFs. This supports the proposed hypothesis (H7.6.2) in the study.

At the construct level, the mean difference (MD=-0.3, $p<0.05$) is comparable to the mean difference observed for environmental performance. At the individual item level/performance measure, the mean difference tightly ranged from -0.3 to -0.4. The results to some extent conform to the findings of Vijayvargy et al. (2017) who found the economic/cost performance of large firms to be significantly higher than that of small and medium firms and contradicts the findings of Zhu et al. (2007), who reported negative association between firm size and economic performance in the Chinese automotive sector. The underlying reasons for the relatively higher economic/cost performance of large firms compared to SMFs are similar to the ones observed for environmental performance such as the relatively high extent of green practices implementation; the relatively high efficiency and effectiveness of green practices implementation; and the relatively high monitoring and reporting of economic/cost performance seen among large firms than SMFs. Again, it is important to note that SMFs are still performing moderately ($M=3.1$) and their performance is not that far behind large firms ($M=3.4$).

10.1.4.3 Impact of firm size on organisational performance

The t-test results on the differences in the extent of improvement in organisational performance among SMFs and large firms are given in Table 10.10.

The results at the construct level show that there is a small but significant difference in the improvement in organisational performance among SMFs and large firms. Large firms were found to perform slightly better than SMFs (MD=-0.2, $p<0.05$). This supports the proposed hypothesis (H7.6.3) in the study. Also, at the individual item/performance measure, a significant difference was found across all measures except an increase in market share (MD=-0.1, $p=1.06$). The mean difference for other measures was tightly ranged between -0.2 to -0.3, all significant at $p<0.05$.

Table 10.9 Differences in the extent of improvement of economic/cost performance among SMFs and large firms

Construct	Included Stakeholders	Mean (SMF)	Mean (Large)	Mean Difference	t-value	Significance	Responses (SMF)	Responses (Large)	Hypothesis supported
All Economic/Cost Performance (combined)	Developer, Contractor, Supplier	3.1	3.4	-0.3	-3.20	0.001***	169	179	Yes
Individual – cost/economic performance									
Reduction in energy expenses	Contractors, Supplier	2.7	3.0	-0.3	-2.04	0.041**	137	151	Yes
Reduction in water expenses	Contractor, Supplier	3.1	3.3	-0.3	-2.50	0.013**	137	151	Yes
Reduction in material expenses	Developer, Contractor, Supplier	3.1	3.5	-0.4	-4.12	0.000***	169	179	Yes
Reduction in waste management expenses	Contractor, Supplier	3.4	3.7	-0.3	-1.86	0.063*	137	151	Yes
Reduction in environmental penalties and fines	Developer, Contractor, Supplier	3.2	3.5	-0.3	-3.49	0.001**	169	179	Yes

Scale: 1 (very low improvement) -5 (very high improvement); ***significance at $p < 0.001$; **significance at $p < 0.01$; *significance at $p < 0.05$

Table 10.10 Differences in the extent of improvement of organisational performance among SMFs and large firms

Construct	Included Stakeholders	Mean (SMF)	Mean (Large)	Mean Difference	t-value	Significance	Responses (SMF)	Responses (Large)	Hypothesis supported
All Organisational Performance (combined)		3.1	3.3	-0.2	-2.256	0.025**	216	239	Yes
Individual – organisational performance									
Increase in sales	Developer, Architect/ Consultant, Contractor, Supplier	3.2	3.4	-0.2	-1.725	0.085*	216	239	Yes
Increase in sales price		3.1	3.4	-0.3	-2.965	0.003**	216	239	Yes
Increase in market share		3.2	3.4	-0.1	-1.622	0.106	216	239	No
Increase in return on investment		3.1	3.3	-0.2	-2.961	0.003**	216	239	Yes
Increase in profits		3.0	3.2	-0.2	-2.695	0.007**	216	239	Yes

Scale: 1 (very low improvement) -5 (very high improvement); ***significance at $p < 0.001$; **significance at $p < 0.01$; *significance at $p < 0.05$

While there is no evidence in the literature to relate the findings to, the study found some evidence from the interviews as to why the organisational performance was higher among large firms than SMFs. For instance, in the case of Developers, significant differences in sales, sales price and profit margin is because large firms tend to associate themselves with large and prestigious projects, which in turn were able to attract environmental conscious western buyers and institutional investors who are more willing to pay the relatively higher price than local buyers. On the other hand, SMFs tend to find buyers in the local market, who as mentioned earlier are aware of the benefits of green buildings or green practices and therefore are not willing to pay a higher price. Similarly, large Architects/Consultants tend to associate themselves with large and prestigious green projects, which in turn can attract more green projects based on the previous reference and also was found to charge a premium from Developers for green projects compared to conventional projects. Again, it is important to note that SMFs are still performing moderately (M=3.1) and their performance is not that far behind large firms (M=3.3).

To summarise the impact of firm size on green performance, some of the key findings and implications for practitioners are as follows:

- All three green performance aspects, environmental, economic/cost and organisational performance of large firms, are slightly higher than that of SMFs.
- SMFs are not that far behind large firms in any of the green performance aspects; this should provide impetus from an environmental and business perspective for the thousands of SMFs in the UAE construction sector to implement green practices.
- There is still significant scope for improvement for both SMFs and large firms in terms of improving green performance as all three green performance aspects are in the moderate range for both SMFs and large firms.

From a theoretical perspective, green performance can be explained on the premise of strategic choice theory. As evidenced from the interviews, it is basically the goal of each firm (large or SMFs) to decide on how much to improve each aspect of performance. Each firm could decide on a win-win situation, where they can work to improve all three performances at the same time

or could go for a trade-off, where the focus is on improving one or two performance aspect by compromising the performance aspect of the other.

10.2 Assessing the impact of firm ownership on GSCM themes/sub-themes

This section will assess the impact of firm ownership on GSCM themes/sub-themes (constructs). The main research question, sub-questions and proposed hypotheses this section will address are given in Table 10.11. Like the assessed the impact of firm size, the impact of ownership on GSCM will be understood by assessing the underlying differences in the GSCM aspects among local and foreign firms. Joint venture firms (foreign-local) are also grouped by the foreign firm category. The rationale for grouping joint venture firms and fully owned foreign subsidiaries is because the GSCM aspects of both firm types were found to be comparable in our interviews. In most cases, it was observed that the joint venture firm involves a western partner with advance green knowledge and skill set. This is also consistent with the findings of previous studies that found ownership differences on GSCM to be less among foreign and joint venture firms but more so with local firms (Zhu et al., 2012). Here also, the survey data across stakeholders (Architects/Consultants, Contractors and Suppliers) will be aggregates, as the overarching objective is to find the impact of firm ownership on GSCM aspects in the construction sector and less so by stakeholder. The Developer is excluded from the analysis, as there are only a handful foreign Developers in the UAE. All the responses obtained from the survey only include local Developers. Like size, the rationale for aggregating the responses from stakeholders (except Developers) is because it was evidenced from the interviews that ownership is more intrinsic to the firm than the stakeholder position in the supply chain. For instance, several ownership-related issues in the interviews were found to be comparable across all stakeholders. Also, this provides a relatively large data set of comparable proportion (n=161 for local and n=234 for foreign firms) to work with that would enhance the generalizability of the results derived from the analysis, though it was not an overarching reason for aggregating the responses. The following sections in sequence will address each research and hypothesis proposed in the study.

Table 10.11 Proposed research question, sub-questions and hypotheses on the impact of firm ownership on GSCM

<i>Main research question: How and to what extent does firm ownership impact GSCM aspects in the construction sector?</i>		
Sub-question 1 (RQ 7.7)	How and to what extent does firm ownership influence the implementation of core and facilitating green practices in the construction sector?	
Hypotheses	H7.7.1	<i>Core green practices' implementation is greater for foreign firms than local firms</i>
	H7.7.2	<i>Facilitating green practices' implementation is greater for foreign firms than local firms</i>
Sub-question 2 (RQ7.8)	How and to what extent does firm ownership influence external green drivers in the construction sector?	
Hypothesis	H7.8.1	<i>Perceived importance/relevance of external drivers is higher for foreign firms than local firms</i>
Sub-question 3 (RQ7.9)	How and to what extent does firm ownership influence internal green drivers in the construction sector?	
Hypothesis	H7.9.1	<i>Perceived importance/relevance of internal drivers is higher for foreign firms than local firms</i>
Sub-question 4 (RQ7.10)	How and to what extent does firm ownership influence external barriers in the construction sector?	
Hypothesis	H7.10.1	<i>Perceived importance/relevance of external barrier is lower for foreign firms than local firms</i>
Sub-question 5 (RQ7.11)	How and to what extent does firm ownership influence external barriers in the construction sector?	
Hypothesis	H7.11.1	<i>Perceived importance/relevance of internal barrier is lower for foreign firms than local firms</i>
Sub-question 7 (RQ7.12):	How and to what extent is the improvement in green performance (in environmental, cost/economic and organisational terms) influenced by firm ownership?	
Hypotheses	H7.12.1	<i>The improvement in environmental performance is higher for foreign firms than local firms</i>
	H7.12.2	<i>The improvement in cost/economic performance is higher for foreign firms than local firms</i>
	H7.12.3	<i>The improvement in organisational performance is higher for foreign firms than local firms</i>

10.2.1 Impact of firm ownership on green practices

Firm ownership was found to impact green practices implementation of firms. This section will attempt to understand the impact of firm ownership on green practices in the construction sector by explicitly comparing the 'extent of implementation of green practices' among foreign and local firms. Like the assessment method used to understand the impact of firm size, an independent sample student t-test is performed to statistically test the differences in the extent of implementation of green practices of local and foreign firms, and descriptive statistics (Arithmetic mean) is used to assess the extent of the differences. Here also, two levels of assessments are carried out, one at the strategic level and the other at the operational/implementation level. At the strategic level, the differences in green practices among local and foreign firms are understood at the construct level, whereas at the operational/implementation level, the differences in green practices are understood at item/factor level. Relevant management/organisational theories are also used to underpin the findings.

This theory enabled understanding on whether local firms are implementing greater, lesser or equal levels of green practices compared to foreign firms has significant strategy and policy implications. It can help practitioners, supply chain stakeholders, investors, non-government organisations and important government policymakers to either develop support mechanisms/frameworks to aid local or foreign firms or both across all supply chain stakeholders and/or develop pressure mechanisms (such as through more stringent or targeted regulations) to promote sector-wide implementation of green practices.

The underlying differences in green practices between local and foreign firms at the construct level are studied by conducting a t-test on the aggregated confirmatory factor analysis (CFA) factor scores obtained from each stakeholder. On the other hand, the underlying differences in green practices between local and foreign firms at the sub-construct or factor/item level are understood by performing a t-test on the aggregated mean scores obtained from each stakeholder. The results of the t-test at the construct level and item/factor level for core and facilitating green practices are given separately in Table 10.12 and 10.13 in line with our proposed hypotheses H7.7.1 and H7.7.2.

10.2.1.1 Impact of firm ownership on core green practices

Table 10.12 shows the underlying differences in the extent of implementation of core green practices at the construct and item/factor level between local and foreign firms.

The results from the table show that the hypothesis H7.7.1 is supported, both at the construct level and at the item/factor level. Therefore, the findings support the literature 'skewness' towards foreign firms implementing more green practices than local firms. As seen from the table, at the construct level, the significant mean difference (MD=-0.4, $p < 0.001$) implies that the extent of implementation of green practices is higher among foreign firms than local firms. At the item/factor level, the differences between local and foreign firms are also significant for each green practice with mean difference ranging from -0.2 for green design to -0.7 for green purchasing.

As mentioned earlier, implementing green practices is a very resource and knowledge intensive task for all stakeholders. Foreign firms, as seen from the interviews, were certainly found to have the edge over their local counterparts in terms of sound knowledge as well as their ability to share/utilise resources of their head office/other branch locations across the world. This is captured in the statement of one of the interviewees from a foreign subsidiary:

"The good thing with us (a foreign contractor) is that we have inherited the entire EMS and other systems from our head office."

Also, previous studies have highlighted that foreign firms could have better access to external financing, state-of-the-art technologies, and cutting-edge practices (Earnhart et al., 2014). For example, in the case of green purchasing, which was found to have the highest difference in the extent of implementation among individual core green practices, foreign firms were found to consider stringent green purchasing practices (above what is required in the tender specifications) such as using EMS and ISO14001 for pre-qualification and conducting frequent supplier audits. This is because foreign subsidiaries in most cases are required to maintain a common environmental protocol across all branches/subsidiaries operating in different countries (Earnhart et al., 2014). On the other hand, for local contracting firms, green purchasing decisions

Table 10.12 Differences in the extent of implementation of core green practices among local and foreign firms

Construct	Relevant Stakeholders	Mean (Local)	Mean (Foreign)	Mean Difference	t-value	Significance	Responses (Local)	Responses (Foreign)	Hypothesis supported
All Core green practices (combined)	Architect/Consultant, Contractor, Supplier	3.5	3.9	-0.4	-3.93	0.000***	161	234	Yes
Individual – core green practices									
Green design	Architect/Consultant, Supplier	4.0	4.2	-0.2	-2.11	0.035**	62	120	Yes
Green purchasing	Contractor, Supplier	3.5	4.2	-0.7	-6.38	0.000***	131	159	Yes
Green transportation	Architect/Consultant, Contractor, Supplier	3.4	3.8	-0.4	-4.08	0.000***	161	234	Yes
Green Construction/Manufacturing	Contractor, Supplier	3.8	4.2	-0.4	-2.93	0.003**	131	159	Yes
End of life green practices	Architect/Consultant, Contractor	3.4	3.70	-0.3	-2.36	0.019**	129	189	Yes

Scale: 1(very low extent) - 5 (very high extent); ***significance at $p < 0.001$; **significance at $p < 0.05$; *significance at $p < 0.1$

Table 10.13 Differences in the extent of implementation of facilitating green practices among local and foreign firms

Construct	Relevant Stakeholders	Mean (Local)	Mean (Foreign)	Mean Difference	t-value	Significance	Responses (Local)	Responses (Foreign)	Hypothesis supported
Facilitating green practices	Architect/Consultant Contractor, Supplier	3.5	4.0	-0.5	-5.48	0.000***	161	234	Yes
Individual -facilitating green practices							161	234	
EMS and ISO 14001		4.0	4.3	-0.3	-3.93	0.000***	161	234	Yes
Environmental training		3.9	4.3	-0.4	-4.23	0.000***	161	234	Yes
Environmental auditing		3.5	4.0	-0.5	-5.07	0.000***	161	234	Yes
Cross functional integration		3.5	4.3	-0.8	-6.89	0.000***	161	234	Yes
Green-related R&D		2.7	3.3	-0.6	-6.18	0.000***	161	234	Yes

Scale: 1(very low extent) - 5 (very high extent); ***significance at $p < 0.001$; **significance at $p < 0.05$; *significance at $p < 0.1$

were mainly targeted at meeting (Developers') contractual requirements. Similarly, for green design, foreign Architects/Consultants were found to have access to their headquarters state of the art 3D modelling software and other tools to come up with the innovative green design.

10.2.1.2 Impact of firm ownership on facilitating green practices

Table 10.13 shows the underlying differences in the extent of implementation of facilitating green practices at the construct and item/factor level. Like core green practices, the results from the table show that the hypothesis (H7.7.2) is supported, both at the construct level and at the item/factor level, i.e. green practices implementation is higher for foreign firms vis-à-vis local firms. The implementation difference at the construct level (MD=-0.5, $p < 0.001$) is significant and higher than the difference seen in the case of core green practices (MD=-0.4, $p < 0.001$). At the item/factor level, the mean differences of individual green practices ranged from -0.3 for EMS and ISO 14001 implementation to -0.8 for cross-functional integration. The findings are in accordance with several studies in other sectors that found facilitating green practices implementation such as EMS and ISO 14001 certifications by foreign firms to be higher than that of local firms (Christmann and Taylor 2001; Neumayer and Perkins 2004).

The results are not surprising as it was evidenced from the interviews that facilitating practices, in general, was higher among foreign firms than local firms across all stakeholders. For instance, the significant difference in the cross-functional integration, which was found to have the highest mean difference among all facilitating green practices, could be because in most of the foreign firms interviewed (across both Architects/Consultants and Contractors), an organisational culture that promotes formal and informal formation of teams and a decentralized/less hierarchical organisational structure was observed. Foreign firms were also found to additionally develop cross-functional teams between head office and the UAE subsidiary. On the other hand, rigid and hierarchical organisational structure was found to be the hindrance for local firms in developing effective cross-functional teams. Similarly, the relatively high mean difference in green-related R&D could well be because foreign firms were found to allocate a good share of revenue/profit as well as time for green-related R&D activities than their local counterparts.

To summarise, the following key aspects (as discussed above) could be reasoned for the underlying differences observed in the country-wide survey:

- Foreign firms have access to resources (both technology and human resources) of their head office/other branch locations across the world. They also have the flexibility in terms of allocating/ reallocating resources across subsidiaries.
- Most foreign firms are required to maintain a common environmental protocol across all branches/subsidiaries.
- Local firms compared to foreign firms have limited technical and managerial know-how in implementing green practices.
- A more supporting organisational structure and culture were seen among foreign firms than local firms.

The finding certainly rejects the pollution-haven hypotheses that foreign firms in developed countries implement lesser or minimal green practices compared to their subsidiaries in developed countries (Eskeland and Harrison, 2003).

From a theoretical perspective, the relatively high core and facilitating green practices implemented by foreign firms can also be explained mainly from the premise of resource based-view and knowledge-based view of firms. It was evidenced from the interviews that foreign firms were found to possess the technical, procedural and managerial know-how as well as access to proprietary assets of headquarters such as EMS and other green technologies vis-à-vis local firms.

Overall, the findings have several implications for practitioners and policymakers. Some of the implications are as follows:

- The cumulative effects of low extent of implementation of a large number of local firms can be a source of environmental risk and a bottleneck in pursuing the goal of a greener supply chain.
- The sector could benefit if all concerned parties work coherently towards improving the green practices of local firms.
- Policymakers and industry leaders could work towards creating a diffusion mechanism (flow of green-related knowledge, skills and expertise from foreign firms to local firms) to

improve the green practices of local firms such as through collaborative partnerships and mentoring opportunities with foreign firms and/or through foreign firms pressurising local firms to implement green practices. Again, the underlying basis is the diffusion of innovation theory (Rogers, 1962). Previous studies have shown that foreign firms, especially those operating in developing countries, are likely to be proactive agents of change for local firms to implement green practices (Child and Tsai, 2005).

Next, the impact of firm ownership on the green drivers in the construction sector will be discussed.

10.2.2 Impact of firm ownership on green drivers

Similar to firm size, the nature of the drivers facing firms, as well as the heterogeneity in firms' responsiveness to these drivers, could vary depending on the ownership of the organisation (Earnhart et al., 2014). This section will attempt to understand the impact of firm ownership on green drivers by comparing the 'perceived importance/relevance of green drivers' among local and foreign firms. Again, an independent sample student t-test is performed to statistically test the difference in the perceived importance/relevance of green drivers of local firms and foreign firms at the strategic/construct level and at factor/implementation level. A small number of relevant management/organisational theories are also used to underpin the findings.

This theory enables understanding at both levels and is important to determine whether firm ownership will play any role in the perceived importance/relevance of these drivers. Determining whether foreign firms are facing more, less or the same extent of pressures or motives compared to local firms is important to enact policies and support mechanisms to ensure all have similar drive in implementing green practices. The following sections will discuss the underlying differences in external and internal green drivers among foreign and local firms.

10.1.2.1 Impact of firm ownership on external drivers

The t-test results on the underlying differences in the external green drivers among foreign and local firms are given in Table 10.14. The results from the table show that the hypothesis (H7.8.1) is not supported at the construct level. Though the external drivers for foreign firms were found to be slightly more than local firms, the difference is not significant (MD=-0.1, p=0.321).

Table 10.14 Differences in the perceived importance/relevance of external green drivers among foreign and local firms

Construct	Relevant Stakeholders	Mean (Local)	Mean (Foreign)	Mean Difference	t-value	Significance	Responses (Local)	Responses (Foreign)	Hypothesis supported
All External Drivers (combined)	Architect/Consultant, Contractor, Supplier	3.0	3.1	-0.1	-0.99	0.321	161	234	No
Individual - external green drivers									
Government green-related regulations	Architect/Consultant, Contractor	3.0	3.3	-0.3	-2.24	0.025**	129	189	Yes
Pressure from supply chain stakeholders	Architect/Consultant, Contractor, Supplier	3.2	3.3	-0.1	-0.91	0.362	161	234	No
Pressure from competitors	Architect/Consultant, Contractor, Supplier	2.9	2.9	0.0	-0.10	0.914	161	234	No

Scale: 1 (very low relevance/importance) - 5 (very high relevance/importance); ***significance at $p < 0.001$; **significance at $p < 0.05$; *significance at $p < 0.1$

Table 10.15 Differences in the perceived importance/relevance of internal green drivers among foreign and local firms

Construct	Relevant Stakeholders	Mean (Local)	Mean (Foreign)	Mean Difference	t-value	Significance	Responses (Local)	Responses (Foreign)	Hypothesis supported
All Internal Drivers (combined)	Architect/Consultant, Contractor, Supplier	3.4	3.9	-0.5	-4.23	0.000***	161	234	Yes
Individual - internal green drivers									
Environmental Commitment	Architect/Consultant, Contractor, Supplier	3.4	4.0	-0.6	-6.35	0.000***	161	234	Yes
Reduce costs	Contractor, Supplier	3.5	3.8	-0.3	-3.10	0.002**	131	159	Yes
Enhance reputation/brand image	Architect/Consultant, Contractor, Supplier	3.5	3.9	-0.4	-3.21	0.001**	161	234	Yes
Enter foreign markets	Architect/Consultant, Contractor, Supplier	3.2	3.8	-0.6	-6.89	0.000***	161	234	Yes

Scale: 1 (very low relevance/importance)- 5 (very high relevance/importance); ***significance at $p < 0.001$; **significance at $p < 0.05$; *significance at $p < 0.1$

However, at the item level, as seen from the table, only the perceived relevance/importance of government regulation was found to be higher for foreign firms than local firms (MD=-0.3, $p<0.05$) as hypothesised. For stakeholder pressure and competitor pressure, the differences were not significant. These results to some extent contrast with the previous literature's findings that foreign firms face more external pressure than local firms (Kim et al., 2016) and that foreign firms take these external pressures more seriously than local firms to maintain good relationships with regulators, supply chain partners and competitors in the host country to eliminate the feeling of 'foreignness' in the host country. Certainly, the findings reject the notion that host country stakeholders regard foreign firms differently from local firms and apply different environmental standards in evaluating them (Kostova and Zaheer 1999; Spencer and Gomez 2011). Also in the interviews, there was no evidence of any such discrimination by governments, consumers and suppliers against foreign firms in the UAE construction sector. However, the only exception in the findings, which is government regulation being perceived higher by foreign firm than local, despite facing the same regulation, could be (as evidenced by the interviews) because foreign firms fear the spill over effect of loss of legitimacy and reputation in one country to another. For example, one of the respondents highlighted that their global supply chain/operations are audited, and compliance to regulation is always at the top of the agenda for auditors. Moreover, foreign firms were found to prepare for more stringent regulations in the future.

10.1.2.2 Impact of firm ownership on internal drivers

The t-test results on the underlying differences in internal green drivers among foreign and local firms are given in Table 10.15. The results show that the hypothesis (H7.9.1) is supported, both at the construct level and at the item/factor level. That implies foreign firms are more driven internally to implement green practices than local firms.

At the construct level, as seen in the table, the mean difference is considerable and significant (MD=-0.5, $p<0.001$). In fact, at the item level too, the results show the consistent and significant difference in each of the internal drivers assessed. As seen in the table, these mean differences ranged from -0.3 for reduce costs to -0.6 for environmental commitment and enter foreign markets, all significant individually at $p<0.05$.

The relatively high difference in the environment commitment driver (MD=-0.6, $p < 0.001$) is in accordance with the literature that suggests foreign firms self-regulate their environmental conduct, participate in voluntary environmental initiatives and adopt internal environmental standards that are more stringent than those mandated by the local governments in developing countries (Dowell, Hart, and Yeung 2000). This high environmental commitment of foreign firms was also evidenced in the interviews. This was mainly because of the foreign firms' corporate (global) environmental policy and to avoid any environmental related reputation risks and inconsistencies in the global operations. For example, one of the foreign Contractors interviewed had, as a part of its headquarters policy, imparted training to more than 350 Subcontractors over the last three years on green/sustainability aspects. No such commitments were found among local firms. Moreover, the high environmental commitment of foreign firms further rejects the pollution-haven hypotheses that foreign firms from developed countries are attracted to weak environmental regulations in developing countries so that there is less need to implement stringent environmental practices (Eskeland and Harrison, 2003; Cole and Elliott 2005; Dean et al., 2009).

With regard to the business motives as green drivers (reduce costs, improve reputation and enter foreign market), the results do echo the notion put forward by Christmann and Taylor (2001) that a firm's environmental strategy depends on the perceived business benefits in the foreign markets and the Porter and van der Linde (1995) argument that foreign firms business wise benefit from higher environmental standards than those in the host country, as it improves their competitiveness and gives immunity once environmental regulation is raised in the host country. Also, Christmann and Taylor (2001) argue that standardising environment strategies across countries can bring cost reduction benefits due to global economies of scale.

Also, it was evidenced from the interviews that foreign owned firms were found to use UAE as a base to operate in neighbouring countries such as Qatar and Saudi Arabia, and which therefore required LEED certification level capabilities (in order to be competitive), whereas local owned firms offered services predominantly locally and did not require green capabilities beyond those required by the regulators and could well explain the differences in entering foreign market. Also, most of the interviewed foreign firms are convinced (because of better knowledge and

awareness) by the cost reduction potential in green projects, whereas a general lack of awareness was found on the business benefits of green practices including cost reduction among local firms.

To summarise the impact of firm ownership on green drivers, some of the key findings and implications for practitioners are as follows:

- All concerned parties need to work together to increase the awareness level of local firms on the business benefits of green practices.
- The commitment to protect the environment is relatively less among local firms than foreign firms. Given the sheer number of local firms, this is a concern in pursuing the goal of a greener supply chain.
- Foreign firms dealing with local firms in the supply chain could exert more pressure on them (stakeholder pressures) to implement green practices

From a theoretical perspective, the high internal drive of foreign firms can be explained through the lens of mimetic cultural-cognitive isomorphism (socio-cultural responsibility), internal legitimacy theory and strategic choice theory. As observed from the interviews, the sociocultural responsibility of protecting the environment was embedded in foreign subsidiaries as part of their corporate (headquarter) culture. Also, from a legitimacy perspective, foreign subsidiaries are expected or forced to implement green practices that are consistent with the foreign headquarter policies. Finally, from a strategic choice perspective, it was observed during interviews that each foreign firm has some degree of freedom and flexibility to pursue environmental strategies to improve their business prospects. As seen here, sometimes multiple theories in combination can better explain a particular GSCM aspect.

Next, the impact of firm ownership on green barriers will be discussed.

10.2.3 Impact of firm ownership on green barriers

Similar to drivers, the perceived importance/relevance of green barriers facing firms as well as the heterogeneity in firms' responsiveness to these barriers could also vary depending on the ownership of the firm. This section will attempt to understand the impact of firm ownership on green barriers by comparing the perceived importance/relevance of these barriers among foreign and local firms. Here also, where relevant, management/organisational theories are used

to discuss the findings. This theory enabled understanding at both levels is important to examine whether ownership plays any role in the firm's ability to overcome/manage these barriers. Like green drivers, determining whether foreign firms are facing more, less or the same extent of barriers compared to local firms is important to enact policies and support mechanisms to ensure all firms develop the capability to minimise/eliminate the impact of these barriers or to undertake prioritized efforts to minimise/eliminate the barriers at the source (in the case of external barriers).

The following sections discuss the underlying differences in external and internal green barriers among foreign and local firms.

10.2.3.1 Impact of firm ownership on external barriers

The results of the t-test conducted to understand the underlying differences in the perceived importance/relevance external green barriers among foreign and local firms are given in Table 10.16.

The results show that at the construct level, the external barriers are less of a concern for foreign firms than local firms (MD=0.6, $p < 0.001$), thereby supporting our proposed hypothesis (H7.10.1).

Also, at the factor/item level, support for the hypothesis was found except for the lack of stakeholder collaboration in which the mean difference emerged to be small and insignificant (MD=0.1, $p = 0.159$). For others, the differences were significant, though they ranged between 0.2 for tight and inflexible stakeholder deadline to 1.0 for shortage of green professionals.

Although there are only limited findings in the literature, it could be reasoned that foreign firms, because of their shared resources, global connections, international experience, skill set and capabilities are in a much better position to manage these externalities than local firms. Also, it was observed in the interviews that foreign firms are more apt at managing these external barriers than local firms. For instance, shortage of green professionals was found to be less of a barrier for foreign firms, because they are able to source the expertise of professionals from their

Table 10.16 Differences in perceived importance/relevance of external green barriers among foreign and local firms

Construct	Relevant Stakeholders	Mean (Local)	Mean (Foreign)	Mean Difference	t-value	Significance	Responses (Local)	Responses (Foreign)	Hypothesis supported
All External Barriers (combined)	Architect/Consultant, Contractor, Supplier	3.6	3.0	0.6	5.77	0.000***	161	234	Yes
Individual - external green barriers									
Shortage of green professionals		3.6	2.6	1.0	8.22	0.000***	161	234	Yes
Shortage of green suppliers		3.7	2.9	0.8	7.31	0.000***	161	234	Yes
Tight and inflexible stakeholder deadlines		3.6	3.4	0.2	1.94	0.053*	161	234	Yes
Lack of stakeholder collaboration		3.4	3.3	0.1	1.41	0.159	161	234	No

Scale: 1(very low relevance/importance) - 5 (very high relevance/importance); ***significance at $p < 0.001$; **significance at $p < 0.05$; *significance at $p < 0.1$

Table 10.17 Differences in perceived importance/relevance of internal green barriers among foreign and local firms

Construct	Relevant Stakeholders	Mean (Local)	Mean (Foreign)	Mean Difference	t-value	Significance	Responses (Local)	Responses (Foreign)	Hypothesis supported
All Internal Barriers (combined)	Architect/Consultant, Contractor, Supplier	3.8	3.2	0.6	-6.38	0.000***	161	234	Yes
Individual – internal green barriers									
High cost of implementation		3.9	3.7	0.2	-2.36	0.019**	161	234	Yes
Lack of knowledge and awareness of green practices		3.7	2.8	0.9	7.99	0.000***	161	234	Yes

Scale: 1(very low relevance/importance) - 5 (very high relevance/importance); ***significance at $p < 0.001$; **significance at $p < 0.05$; *significance at $p < 0.1$

head office. For example, most of the interviewed foreign Architects/Consultants were also found to shift employees from head office or other branches to the UAE on a temporary project basis to address the shortage of green professionals. Similarly, the shortage of green suppliers is less of a barrier for foreign firms because they were found to have strong international partnerships with global (green) suppliers, plus they were found to use their parent company or headquarter purchasing power to obtain favourable credit terms and earliest possible delivery schedule. On the other hand, local firms were struggling to establish a good, long term relationship including availing of favourable credit terms with overseas green suppliers. Also, with regards to the tight and inflexible deadline, it could be argued that the barrier is lower for foreign firms because they are in a relatively stronger position (because of their resource capability and knowledge level) than local firms to negotiate deadlines with Developers. However, the perplexing finding that needs to be explored further is the small and insignificant difference in lack of stakeholder collaboration despite the expectation that it would be lower for foreign firms based on our interview findings. In the interviews, it was observed that stakeholders, especially Developers, are more open for engagement/collaboration with foreign firms than local firms because of their strong confidentiality and data integrity policies and the trust with the parent company.

10.2.3.2 Impact of firm ownership on internal barriers

The results of the t-test conducted to understand the underlying differences in the perceived importance/relevance of internal green barriers among foreign and local firms are given in Table 10.17.

Like external barriers, the results show that the internal barriers are also less of a concern for foreign firms than their local counterparts, thereby supporting our proposed hypothesis (H7.11.1), both at the construct level and at each of the item/factor level.

At the construct level, the mean difference is considerable and significant (MD= 0.6, $p < 0.001$). Also, the results at the item/factor level show that the differences are significant across the two internal barriers assessed, the high cost of implementation (MD=0.2, $p < 0.05$) and lack of knowledge and awareness (MD=0.9, $p < 0.001$). The findings support the evidence in the literature that foreign firms have better access to external financing, state-of-the-art technologies,

advanced management systems, procedural know-how and cutting-edge practices (Earnhart et al., 2014; Kim et al., 2016). Also from the interviews, it was evident that foreign firms had easy access to global tools and expertise available at headquarters. Furthermore, continuous knowledge transfer processes were observed to be happening from head office to the UAE office on all aspects including green-related. Further, employees in the UAE office of these foreign firms are sent to head office for training.

To summarise the impact of firm ownership on external and internal green barriers, some of the key findings and implications for practitioners are as follows:

- Foreign and local firms perceive same barriers differently. For example, foreign firms consider the lack of local green suppliers (which is same for all firms) to be less of a barrier than local firms because of their ability to manage the barriers such as their strong international partnerships and headquarter purchasing power.
- The sector in general will benefit if some form of support mechanisms is provided to local firms to manage these barriers.
- Before enacting any green regulations, the government should take into consideration the constraints facing local firms as too many regulations can become a burden to local firms to comply.
- Foreign firms dealing with local firms in the supply chain could proactively work towards improving the knowledge and awareness level and expertise of local firms.

From a theoretical perspective, the impact of firm ownership on green barriers can be explained from a resource and knowledge based view. As evidenced from the interviews and in the literature, foreign firms, because of their vast resources and knowledge, are able to better manage these barriers than local firms.

Next, the underlying differences in performance (environmental, cost/economic and organisational) of both foreign and local firms will be discussed.

10.2.4 Impact of firm ownership on green performance

The impact of firm ownership on green performance across all three dimensions is understood by performing a t-test on the extent of improvement of environmental, cost/economic and

organisational performance separately for foreign and local firms. Again, two levels of assessments are carried out, strategic level and operational/implementation level.

The following sections will discuss separately the underlying differences in environmental, cost/economic and organisational performance among foreign and local firms

10.2.4.1 Impact of firm ownership on environmental performance

The t-test results on the differences in the extent of improvement of environmental performance among foreign and local firms are given in Table 10.18. The results at the construct level show that the differences in the extent of improvement in environmental performance are significant, with foreign firms demonstrating higher performance than local firms (MD=-0.3, $p<0.05$). This supports the proposed hypothesis (H7.12.1) in the study. Although the evidence in the literature is very limited, it was expected that foreign firms would have higher performance than local firms given that it was found in the earlier sections that foreign firms are more internally motivated, they better manage barriers and implement green practices higher and better than local firms.

At the individual item/factor, not surprisingly 6 out of 7 individual performances assessed were found to be significantly higher for foreign firms with mean difference ranging from -0.2 for a reduction in hazardous material use to -0.4 for reduction in greenhouse gas emissions. The only measures for which the difference emerged to be insignificant is reduction in environmental accidents. The related justification is the similar to what have been provided earlier with regards to firm size, as most firms have a 'generic accidents' policy as part of the stringent health and safety regulations, and most of the firms, especially local firms were found to monitor it very seriously. For the other measures, the significant improvement is not surprising given the various aspects for foreign firms discussed throughout this section. For instance, the relatively high extent of green implementation of foreign firms vis-à-vis local firms (as seen in sections 10.2.1.1 and 10.2.1.2), could be argued as one of the reasons for the relatively high environmental performance of foreign firms. The other reason evidenced from the interviews is the relatively high efficiency and effectiveness of their green practices implementation of foreign firms than local firms because of their superior knowledge, experience and tools. In addition, the stringent monitoring and reporting of environmental performance measures, especially to their head

Table 10.18 Differences in the extent of improvement of environmental performance among foreign and local firms

Construct	Included Stakeholders	Mean (Local)	Mean (Foreign)	Mean Difference	t-value	Significance	Responses (Local)	Responses (Foreign)	Hypothesis supported
All Environmental Performance (combined)	Architect/Consultant, Contractor, Supplier	3.6	3.9	-0.3	-2.69	0.007**	161	234	Yes
Individual – environmental performance									
Reduction in environmental accidents		3.9	4.0	-0.1	-0.72	0.468	161	234	No
Reduction in greenhouse gas emissions have decreased		3.5	3.9	-0.4	-3.03	0.003**	161	234	Yes
Reduction in water consumption		3.7	4.0	-0.3	-3.37	0.000***	161	234	Yes
Reduction in energy consumption		3.7	4.0	-0.3	-3.21	0.001**	161	234	Yes
Reduction in landfill waste		3.5	3.8	-0.3	-2.82	0.005**	161	234	Yes
Reduction in material use		3.3	3.6	-0.3	-2.36	0.019**	161	234	Yes
Reduction in use of hazardous materials		3.9	4.1	-0.2	-1.81	0.070*	161	234	Yes

Scale: 1 (very low improvement) -5 (very high improvement); ***significance at $p < 0.001$; **significance at $p < 0.01$; *significance at $p < 0.05$

office (foreign firms were found to include subsidiary results including environmental aspects in their corporate annual report) have enabled them to make corrective actions in their existing green practices and consequently further improve their environmental performance.

However, it is important to note that despite the foreign firms superior technical and managerial know how and resources, local firms overall are also performing reasonably well (M=3.6) and that they are not that far behind foreign firms (as the mean difference is only -0.3).

10.2.4.2 Impact of firm ownership on economic/cost performance

The t-test results on the differences in economic/cost performance among foreign and local firms are given in Table 10.19. The results at both the construct level shows that the differences in the extent of improvement in economic/cost performance are significant (MD=-0.3, $p < 0.1$), with foreign firms demonstrating slightly higher performance than local firms. This supports the proposed hypothesis (H7.12.2) in the study.

However, at the individual item level/performance measure, 2 out of 5 measures, namely reduction in waste management expenses and environmental penalties and fines, emerged to have a non-significant difference. These non-significant differences can be reasoned based on the findings from the interviews. For example, respondents from foreign Contractors highlighted they implement comprehensive waste management practices, which is resource and time intensive. It includes careful segregation of waste such as reusable waste, recyclable waste and landfill waste. While this practice reduces land fill taxes and related transportation expenses, the resource intensive nature of the practices offset some of the former benefits. This could explain why the reduction in waste management expenses is not as high as expected with foreign firms. For reduction in environmental fines and penalties, some of the local firms highlighted that they closely monitor it as part of their generic risk management framework.

For the others, the differences are significant, and the mean difference ranged from -0.2 for energy expenses to -0.4 for material expenses. The significant differences are expected as foreign firms were found to do close monitoring of economic/cost performance, and report performance results to head office as part of corporate key performance indicators.

Table 10.19 Differences in the extent of improvement of economic/cost performance among foreign and local firms

Construct	Included Stakeholders	Mean (Local)	Mean (Foreign)	Mean Difference	t-value	Significance	Responses (Local)	Responses (Foreign)	Hypothesis supported
All Economic/Cost Performance (combined)	Contractor, Supplier	3.3	3.6	-0.3	-1.78	0.075*	131	159	Yes
Individual – Economic/cost performance									
Reduction in material expenses		3.0	3.4	-0.4	-3.67	0.000***	131	159	Yes
Reduction in water expenses		3.3	3.6	-0.3	-2.74	0.006**	131	159	Yes
Reduction in energy expenses		3.4	3.6	-0.2	-1.92	0.055*	131	159	Yes
Reduction in waste management expenses		3.4	3.5	-0.1	-1.41	0.159	131	159	No
Reduction in environmental penalties and fines		3.5	3.6	-0.1	-0.99	0.321	131	159	No

Scale: 1 (very low improvement) -5 (very high improvement); ***significance at $p < 0.001$; **significance at $p < 0.01$; *significance at $p < 0.05$

Again, it is important to note that the differences in the improvement are not that high (as the mean difference is only -0.3), and show that local firms too can achieve cost/economic performance. However, as seen from the table, there is still much scope for improvement for both foreign and local firms as the overall performance is 3.6 and 3.3 respectively.

10.2.4.3 Impact of firm ownership on organisational performance

The t-test results on the differences in the organisational performance among local and foreign firms are given in Table 10.20.

The results at the construct level show that there are no significant differences in the improvement in organisational performance among foreign and local firms. Therefore, the proposed hypothesis (H7.12.3) is not supported. Also, at the individual item/performance measure, no significant difference was found across all measures except for an increase in sales price (MD=-0.3, $p < 0.05$).

Overall, the findings are encouraging from a local firm perspective as they too are able to achieve long term organisational performance benefits from implementing green practices. Still, as seen from the table, there is still plenty of scope for improvement for both foreign and local firms as the overall performance is 3.4 and 3.2 respectively.

To summarise the impact of firm ownership on green performance, some of the key findings and implications for practitioners are as follows:

- These findings show that 'being green pays' both in the short run and long run, for both local and foreign firms, and should therefore substantially encourage all firms to implement green practices from a business perspective.
- Local firms are not that far behind foreign firms in any of the green performance aspects. This should provide impetus for local firms in the UAE construction sector to implement green practices both from an environmental and business perspective.
- There is still significant scope for improvement for both local and foreign firms in terms of improving green performance as all three green performance aspects are in the moderate range for both local and foreign firms.

Table 10.20 Differences in the extent of improvement of organisational performance among foreign and local firms

Construct	Included Stakeholders	Mean (Local)	Mean (Foreign)	Mean Difference	t-value	Significance	Responses (Local)	Responses (Foreign)	Hypothesis supported
All Organisational Performance (combined)	Architect/Consultant , Contractor, Supplier	3.2	3.4	-0.2	-0.913	0.362	161	234	No
Individual – organisational performance									
Increase in sales		3.3	3.4	-0.1	-0.727	0.468	161	234	No
Increase in sales price		3.2	3.5	-0.3	-2.120	0.035**	161	234	Yes
Increase in market share		3.3	3.5	-0.2	-1.620	0.106	161	234	No
Increase in return on investment		3.2	3.3	-0.1	-0.413	0.680	161	234	No
Increase in profits		3.1	3.2	-0.1	-0.139	0.890	161	234	No

Scale: 1 (very low improvement) -5 (very high improvement); ***significance at $p<0.001$; **significance at $p<0.05$

To conclude, this chapter provided a comprehensive picture of the impact of firm size and firm ownership. The results in general show that firm size and ownership had a significant impact on several aspects of GSCM and therefore shows that addressing the impact of size and ownership should not be overlooked for greening the construction sector. Policymakers, industry leaders, practitioners and other interested parties should work together to develop a support/pressure mechanism to ensure all firms, regardless of their size and ownership are implementing extensive, efficient and effective green practices leading to improved performance across all three dimensions. None of the previous studies in any sector, let alone construction, has conducted a comprehensive investigation on the impact of firm size and ownership on GSCM and is therefore, a significant and novel contribution to the GSCM literature.

Chapter 11 – Implication and Conclusions

In this final chapter, first, a brief review of the research background and process carried out is provided. Next, the chapter briefly revisits the findings of this study in relation to the research questions and highlights its contributions to theory and practice. Finally, the limitations of this study along with avenues for future research are discussed.

11.1. Research background and process

This thesis has studied green supply chain management, a systematic and integrated approach to greening the construction sector, which among the sectors is observed as the single largest contributor to environmental pollution, climate change and resource depletion. It includes understanding the potential green practices, drivers and barriers affecting the implementation of these green practices and the performance outcomes of these green practices, namely, environmental, economic/cost and organisational performance for each of the key supply chain stakeholders (Developers, Architects/Consultants, Contractors and Suppliers). Also, the study looked at the impact of firm size and ownership on GSCM since comprehensive greening the construction sector would not be possible without understanding the implications of size and ownership on GSCM. Each of these GSCM aspects, i.e. green practices, green drivers and barriers, and green performance and their interrelationships, and the impact of firm size and ownership on GSCM are investigated as separate research questions in this thesis. A pragmatic approach, a combination of both qualitative (exploratory and in-depth interviews) and quantitative investigation (a structured country-wide survey) was used to comprehensively answer each research questions.

11.2. Discussion on research questions

The central aspect of this thesis is the seven research questions proposed. This section will revisit the answers to each research questions and its contribution to theory and practice.

Research question 1

What are the core and facilitating green practices implemented by individual construction sector stakeholders and the extents of their implementation?

The important core green practices (or activities/initiatives undertaken to minimise the environmental footprint across each of the distinct functional stages of the supply chain) identified in this study in greening the construction sector include green design, green purchasing, green transportation, green construction/manufacturing and end of life green practices. However, the extent of implementation of relevant core green practices was found to be uneven across stakeholders. Overall, it was found to be highest among Suppliers, followed by Contractors, Architects/Consultants and Developers. Also, certain core green practices, in general, such as green transportation and end of life green practices, were found to lag other green practices across all stakeholders.

The important facilitating green practices (or activities/initiatives undertaken at an intra-firm level to build internal resources and capabilities to achieve environmental goals) identified in this study for greening the construction sector include environmental management systems (EMS) and ISO 14001 certification, cross-functional integration, environmental auditing and environmental training and green-related research and development. Like core green practices, the extent of implementation of facilitating green practices was also found to be highest among Suppliers and lowest among Developers.

Overall, the current level of core and facilitating green practices implementation (except for Suppliers) is moderate and shows there is significant scope for the sector to improve its green practices implementation. Also, the high standard deviation ($SD > 1$) observed for several constructs points to a lack of consistency in the implementation across firms, with some firms within each stakeholder having relatively high extents of implementation than others.

A detailed understanding on each of these core and facilitating green practices, particularly practices such as green transportation, end of life green practices, cross-functional integration and green-related research and development, including their relevance/non-relevance and extent of implementation for each stakeholder has not been undertaken previously in the construction sector and significantly adds to the novelty of this study. Also, among the findings, importance/relevance of green-related research and development as a facilitating/supporting green practice has not been identified previously in any sector let alone construction and hence makes a novel contribution to the generic GSCM literature.

The findings have importance in the construction sector because previously practitioners and each stakeholder had limited understanding regarding the nature and details of different core and facilitating green practices they could have implemented in their respective firms. The findings provide practitioners in the UAE and elsewhere with a potential stock of core and facilitating green practices that can be adopted by each stakeholder in greening the construction supply chain. This includes simple green practices such as the use of video conferencing instead of face to face meeting (within green transportation) to complex green practices such as the use of energy efficient machinery in onsite construction. This implies that firms with limited knowledge and resource constraints can start by implementing simple green practices and then gradually move towards more complex green practices. The findings are also useful for policymakers to prioritise their actions, strategies and policy interventions to create support/pressure mechanisms to improve those green practices that are lagging others.

From a research/theoretical perspective, the study have validated and operationalised core green practices as a second-order construct and facilitating green practices as the first-order construct. This itself is a significant research contribution given that construct development and validation is at the heart of theory building (Venkatraman 1989) and the study significantly contributes towards the theoretical advancement of GSCM. Also, several established/emerging management/organisational theories that offer a plausible basis to explain the behaviour of stakeholders in implementing core and facilitating green practices are discussed. These include strategic choice theory, resource and knowledge-based views and resource-dependence theory.

Overall, this research question (RQ1) was comprehensively answered in this thesis. A comprehensive investigation of this stature to assess the various green practices in the construction sector has not been undertaken previously and therefore it significantly adds to the research contribution of this study.

Research question 2

What are the green drivers and barriers (external and internal) for implementing green practices (core and facilitating) for individual construction sector stakeholders and their perceived importance/relevance?

The important external green drivers (external forces/pressures that coerce firms to implement green practices) identified in this study are government green-related regulation, supply chain stakeholder pressure, competitor pressure and buyer/end-consumer pressure. The perceived relevance/importance of external drivers, in general, was found to be (relatively) high among Architects/Consultants and Contractors. Also, relevance/importance of certain external drivers such as end-consumer/buyer pressure was found to be very low compared to others.

The important internal green drivers (internal forces/pressures that motivate firms to implement green practices) identified in this study either emerged from corporate responsibility/concern for the environment and/or to achieve clearly stated business benefits. These include the environmental commitment of firms, enhance reputation/brand image, to reduce costs and to enter foreign markets. However, the perceived relevance/importance of these internal drivers was found to vary considerably across stakeholders. Overall, the internal drive was found to be highest among Suppliers, followed by Architects/Consultants, Contractors and Developers.

Overall, the results on green drivers show that all stakeholders except Developers are more motivated internally than externally to engage in green practices. In the case of Developers, external pressures from government authorities and competitors emerged as the dominant drivers for implementing green practices. Still, the perceived relevance/importance of both external and internal pressures for Developers is relatively lower than other stakeholders. For Architects/Consultants, stakeholder pressure emerged to be the dominant driver, although they were found to consider all internal drivers to be equally and moderately important/relevant. Contractors were found to consider all green drivers (except competitor pressure) to be moderately relevant/important. For Suppliers, it was clear that they are driven internally as all the internal drivers were found to be highly relevant/important, whereas external drivers were found to be only low/moderately low. Still, the high standard deviation ($SD > 1$) for external and internal drivers for Developers and Contractors demonstrate considerable variation in the ways firms within these stakeholders perceive these pressures.

The important external barriers (external impeding forces that hinder or restricts firms from implementing green practices) identified in this study are shortage of green professionals, shortage of green suppliers, tight and inflexible stakeholder deadline and lack of stakeholder

collaboration. Although the perceived relevance/importance of external barriers was only moderate across stakeholders relatively, it was found to be highest among Contractors, followed by Architects/Consultants, Suppliers and Developers.

The important internal barriers identified in this study are the high cost of implementation and lack of knowledge and awareness. All stakeholders were found to perceive internal barriers to be moderately important/relevant, though it was relatively lower for Architects/Consultants.

Overall, it was found that Developers and Suppliers perceived internal barriers more than external, while in the case of Architects/Consultants and Contractors, the perceived external and internal barriers emerged to be more or less the same. Among the barriers (external and internal), the high cost of implementation, in general, emerged as the dominant barrier across all stakeholders. Again, a high standard deviation ($SD > 1$) in external and internal drivers was identified for some of the stakeholders such as external and internal barriers for Architects/Consultants; this implies that some firms (within each stakeholder) are considering these barriers to be more relevant/important than others.

The findings provide practitioners and policymakers in the UAE and elsewhere with a potential stock of external and internal green drivers, and external and internal barriers, affecting the implementation of green practices across all stakeholders so that they could consider management levers to leverage green drivers and/or eliminate green barriers. The green drivers and barriers identified also include several new drivers and barriers, which have not been identified previously in the construction literature. These include consumer pressure, enter foreign market and tight and inflexible stakeholder deadline. In fact, tight and inflexible stakeholder deadline as a barrier has not been identified previously in any sector let alone construction and therefore adds to the generic GSCM literature.

In terms of research contribution, this study has validated and operationalised four first-order constructs, namely external drivers, internal drivers, external barriers and internal barriers.

With regard to theoretical contribution, the study proposes several established/emerging theories to understand the various green drivers and barriers affecting the implementation of green practices. Specifically, external drivers are understood through the lens of institutional

isomorphism (coercive, normative and mimetic); internal drivers through the lens of cultural-cognitive (socio-cultural responsibility) isomorphism, strategic choice theory, and transaction cost economics theory; external barriers through the lens of knowledge-based view, resource-dependence theory, stakeholder theory and agency theory; internal barriers through the lens of resource and knowledge based view. The application of several established/emerging theories to understand the various green drivers and barriers has not been undertaken previously in the construction sector and hence constitutes a novelty.

Overall, this research question (RQ2) was comprehensively answered in this thesis. No previous study in the construction sector has conducted a comprehensive investigation to understand relevant green drivers and barriers affecting the implementation of green practices across stakeholders and therefore adds to the research contribution of this study.

Research question 3

What green performance measures (in environmental, cost/economic and organisational terms) are used by individual construction sector stakeholders and the extents of improvement in them from implementing green practices (core and facilitating)?

The relevant and important performance measures identified in this study to capture environmental performance (the ability of the firm or sector to minimise the adverse impact it has on the natural environment) include a reduction in environmental accidents, greenhouse gas emissions, water consumption, energy consumption, material use, and waste generated. The measures were found to be relevant for all stakeholders. However, the actual improvement in environmental performance was found to vary considerably across stakeholders. Overall, the improvement in environmental performance was found to be highest for Suppliers, followed by Contractors, Architects/Consultants and Developers (lowest). Although the overall improvement in economic/cost performance was relatively lower than the improvement in environmental performance, the improvement was again found to be highest for Suppliers and lowest for Developers. In fact, for Developers the improvement in economic/cost performance was found to be very low. For organisational performance, again the improvement in performance was found to lowest for Developers, whereas for other stakeholders it was found to consistent and

moderate. The relatively low green performance for all three aspects for Developers is a grave concern for the UAE construction sector from a greening perspective, given that Developers are the ones who initiate green projects.

The findings have several practical implications. Since firms cannot effectively manage what they do not measure, this understanding provides practitioners with simple, standardised, easy to operationalise performance measures to capture the green performance of firms. The most significant and novel contribution is the operationalisation of organisational performance measures to capture the long-term business benefits of green practices. None of the previous studies in the construction sector has looked at implementing green practices from a long-term investment perspective. Next, the actual improvement in green performance shows that except economic/cost performance for Developers, all stakeholders have been able to improve all three green performance aspects. This significant “win-win” opportunities identified in the study should provide the impetus for firms to implement green practices in the construction sector. However, in line with firms performance goals, firms can also choose strategically to decide on improving all three performance aspects or settle for trade-off as seen in the case with Developers between economic/cost performance or organisational performance (firms should not compromise environmental performance, as the *raison d'être* for implementing green practices is improving environmental performance)

Regarding research contribution, the study validates and operationalizes all three green performance dimensions as first-order constructs. Researchers could use these validated performance constructs to gauge the green performance of their respective construction sector contexts.

The study also proposes several established/emerging theories to underpin the findings related to the use of green performance measures and the actual improvement in green performance. Specifically, the application of environmental performance measures and subsequent increase in performance can be better understood using legitimacy theory, whereas the application of economic/cost and organisational performance measures and subsequent increase in performance can be understood using transaction cost economics theory.

Overall, this research question (RQ3) was comprehensively answered in this thesis. The study overcomes the lack of consistency and limited understanding on the use of green performance measures for various stakeholders in the construction sector. Moreover, none of the studies in the construction sector has either used organisational performance measures or reported organisational performance, which is a significant contribution to this study.

Research question 4

How and to what extent do green drivers and barriers (external and internal) impact green practices (core and facilitating) for individual construction sector stakeholders?

Two levels of assessments are carried out in this study, namely strategic level assessment (at the sector) and operational/implementation level assessment (at the firm level) to comprehensively answer the research question.

Strategic level

The strategic level assessment carried out using the data collected from the country-wide survey was critical in understanding to what extent the internal and external pressures/motives have translated into organisational actions or to what extent internal and external barriers/challenges have translated into organisational inactions at the sector level. Overall, the findings show that the extent of the impact of green drivers on green practices far exceeds the extent of the impact of green barriers on green practices, and therefore self-explains the moderate extent of implementation of green practices. However, there is plenty of scope to improve the impact of green drivers on green practices and minimise/eliminate the impact of green barriers on green practices. The findings also show that the stakeholders (except Developers) are more proactive in implementing green practices (i.e. impact of internal green drivers on green practices is higher than the impact of external green drivers on green practices).

Since the extent of green practices implementation would depend on the net force field impact of opposing pressures of drivers and barriers, the findings are useful for policymakers and industry leaders to predict the sector's green behaviour and to devise strategies for each stakeholder so that they can maximise/leverage the drivers and minimise/eliminate the barriers to promote sector-wide efficient and effective green practices' implementation.

In terms of research contribution, it validates the model fit of the strategic level GSCM driver-barrier-practice model (Figure 3.4, chapter 3). Future researchers could use/adapt this model in their respective context. Regarding theoretical contribution, the study introduces Lewin's Force Field theory for reasoning the net impact of green drivers and barriers on green practices. To the best of my knowledge, this is the first application of Lewin's force field theory in GSCM and hence adds to the novelty of this study.

Operational/implementation level

The operational level assessment carried out using the data collected from the in-depth interviews was critical in understanding the impact of individual green drivers and barriers on individual green practices at an in-depth firm level. This knowledge at the firm level is important since individual green drivers and barriers could impact each green practice's implementation differently.

The results show that some green drivers, such as government regulation, have a narrow but strong impact on few green practices, whereas some drivers such as environmental commitment and enhance reputation/brand image was found to have broad and strong/moderate impact on several green practices. Similarly, some green barriers such as shortage of green suppliers were found to have a narrow and moderate impact on few green practices, whereas others such as high cost of implementation were found to have a broad and strong/moderate impact on several green practices.

The operational level findings are useful for practitioners looking to improve any specific green practice as they could easily make sense of all the green drivers and barriers affecting that practice and therefore can choose to decide on prioritising actions for maximising/leveraging all or select green drivers and/or minimising/eliminating all or select green barriers that impact that green practice.

In terms of research contribution, a one to one assessment of the impact of green drivers and barriers on green practices has not been undertaken previously in any sector let alone construction and can be considered as a methodological contribution to GSCM.

Overall, this research question (RQ4) was comprehensively answered in this thesis.

Research question 5

How and to what extent do green practices (core and facilitating) impact green performance (environmental, cost/economic and organisational) for individual construction sector stakeholders?

Again, two levels of assessments, strategic level and operational/implementation level was carried out in this study to comprehensively answer the research question.

Strategic level

The strategic level assessment that was performed using the data collected from the country-wide survey was critical in understanding the extent to which the green practices implementation have translated into actual performance. This is important because the high extent of green practices implementation does not necessarily translate into high performance. Instead, it will also depend on the efficiency and effectiveness of the green practices implementation as well as the alignment of the green practices towards the intended performance outcomes.

Overall, the findings show that both core and facilitating green practices were found to have a positive and significant impact on three dimensions of performance across all stakeholders. Also, the strength of impact, in general, ranged from moderate to high, though there is still scope for improvement.

For practitioners, the significant “win-win” opportunities for all stakeholders should provide the impetus for construction sector firms to implement green practices. For policymakers, the results are useful to gauge the efficiency and effectiveness of both core and facilitating green practices implementation in the construction sector and if required, they can undertake strategies, actions and policy interventions to improve the efficiency and effectiveness of green practices’ implementation.

In terms of research contribution, it validates the model fit of the strategic level GSCM practice-performance model (Figure 3.5, chapter 3). Future researchers could use/adapt this model in their respective contexts. From a theoretical standpoint, the strength of the impact of core and facilitating green practices on performance was understood through complexity theory.

Operational/implementation level

The operational level assessment carried out using the data collected from the in-depth interviews was critical to understanding the role and contribution of individual green practices on each dimension of performance. The findings show that some green practices such as green purchasing and green-related R&D had narrow and moderate impact on few green performance aspects across relevant stakeholders, whereas some green practices such as environmental auditing and green construction/manufacturing were found to have broad and moderate/strong impact on all green performance aspects across all relevant stakeholders

From a practitioner's perspective, this finding is useful to quickly and easily make sense of the potential benefits of each green practice and subsequently could prioritise the implementation of those individual facilitating and/or core green practices that deliver the firm's targeted green performance goals (taking all three performance aspects into consideration).

In terms of research contribution, the one to one assessment on the impact of green practices on green performance has not been undertaken previously in the construction sector and hence adds to the GSCM literature on construction.

Overall, this research question (RQ5) was comprehensively answered in this thesis.

Research question 6

How and to what extent do facilitating green practices impact core green practices for individual construction sector stakeholders?

Again, two levels of assessments, strategic level and operational/implementation level were carried out in this study to comprehensively answer the research question.

Strategic level

The strategic level assessment was critical in understanding the impact of firm level internal resources and capabilities (facilitating green practices) on their core green practices implementation. The results show that facilitating green practices, in general, had a strong and positive impact on core green practices.

This supports the argument that facilitating green practices is a necessary precursor to the implementation of core green practices. The findings also support the arguments of policymakers looking to make facilitating green practices (few or all of them) mandatory for construction firms or looking to devise support mechanism for firms to implement facilitating green practices.

In terms of research contribution, it validates the model fit of the strategic relationship model to assess the impact of facilitating green practices on core green practices (Figure 3.6, chapter 3). Future researchers could use/adapt this model in their respective context.

Regarding theoretical contributions, the study introduces implementation theory impact to understand the impact of facilitating green practices on core green practices. The application of implementation theory in GSCM has not been undertaken and hence adds to the novelty of this study.

Operational/implementation level

The operational/implementation level assessment was critical in understanding how each facilitating green practice is impacting each core green practice. The results showed that some facilitating green practices such as green-related R&D had a narrow and moderate impact on few core green practices across stakeholders, whereas other green practices such as environmental auditing had relatively broad and moderate/strong impact on several core green practices across stakeholders.

This understanding is critical for practitioners to prioritise the implementation of those facilitating green practices first that have a broad and strong impact on core green practices. Similarly, this understanding would be useful for corporate managers to know whether their investment in developing internal resources and capabilities (facilitating green practices) is helping their external or core green practices.

The operational level findings further support the argument that facilitating green practices is a necessary precursor to the implementation of core green practices.

In terms of research contribution, the one to one impact of facilitating green practices on core green practices has not been undertaken previously in any sector let alone construction and can be considered as a methodological contribution to GSCM.

Overall, this research question (RQ6) was comprehensively answered in this thesis.

Research question 7

How and to what extent do firm size and firm ownership influence GSCM aspects in the construction sector?

Assessing the impact of firm size and firm ownership is critical, as greening the supply chain would not be effective without the active involvement and participation of all firms regardless of their characteristics. The results showed significant differences in the green practices implementation, i.e. the core and facilitating green practices implementation was higher for large firms vis-à-vis small and medium firms (SMF) and higher for foreign firms vis-à-vis local firms. Also, with regards to perceived importance/relevance of green drivers and barriers, the results in general (except the perceived importance/relevance of external drivers between local and foreign firms) showed significant difference, i.e. the perceived importance/relevance of external drivers were higher for SMFs than large firms; internal drivers were higher for large firms vis-à-vis SMFs and higher for foreign firms vis-à-vis local firms; external and internal barriers were higher for SMFs vis-à-vis large firms and higher for local firms vis-à-vis foreign firms. The extent of improvement in green performance (except organisational performance between local and foreign firms) also showed significant difference, i.e., the extent of improvement in three green performance aspects, namely environmental, economic/cost and organisational performance of large firms, were slightly higher for large firms vis-à-vis SMFs and the extent of improvement in two green performance aspects, namely environmental and economic/cost performance were slightly higher for foreign firms vis-à-vis local firms.

These findings are important for policymakers, industry leaders and practitioners and other interested parties to work together to devise actions, strategies and policy interventions to ensure the green practices implementation, consequent green performance and

ability/capability in leveraging drivers and minimising/eliminating barriers of SMFs and local firms are comparable to that of large firms and foreign firms respectively.

Regarding research contribution, none of the previous studies in any sector, let alone construction, have conducted a comprehensive investigation on the impact of firm size and ownership on GSCM and therefore this is a significant and novel contribution to the GSCM literature.

Furthermore, the study has used several management/organisational theories, namely the resource and knowledge based view, the strategic choice theory, diffusion of innovation theory, legitimacy theory are discussed to render deeper, broader and simplified understanding of the impact of firm size and firm ownership on GSCM.

11.3. Individual supply chain stakeholders' contribution to greening the construction sector

As mentioned earlier, the overall green performance of the sector is the sum total of the green performance of the individual supply chain stakeholders, namely, Developers, Architects/Consultants, Contractors/Subcontractors and Suppliers. While answering research questions RQ1-RQ6, some of the key contributions of each individual stakeholder identified towards greening the construction sector are as follows.

Developers

Since Developer is the one who initiates the project and the one who enjoys a hierarchical position with power in the supply chain to influence the whole project, green decisions made by Developers was found to have a strong impact on the overall green performance of the construction project and consequently the sector. The study found that the green design goals of the project are defined by the Developers at the pre-design, project concept definition stage. For example, Developer may decide on only meeting the minimum green building regulations or may decide on going over and above the green building regulations such as achieve LEED Gold certifications. Therefore, the environmental commitment or environmental/financial goals of the Developer was found to impact the greening of the various stages of the supply chain, from the initial environmental impact assessment of the project to final end of life green practices. For

instance, the rigour in the environmental impact assessment of Developers, which ensures the surrounding flora and fauna of the building is not impacted by the building construction/operation, is important from an environmental perspective. Similarly, the Developer is responsible for finalizing the green design of the building. This choice and extent of design decision such as natural ventilation, natural lighting, waste water recycling system and energy efficient heating and lighting system were found to have a lasting impact on the life-cycle environmental performance of the project. This is important, given that environmental considerations made during design stage (green design) could significantly and directly reduce the environmental impacts during the operational phase of building [responsible for 80% of the total life cycle environmental impact according to Ng et al. (2012)], 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).

Similarly, green purchasing decisions made by Developer was found to have an impact on the overall environmental performance of the project. This is because, it is up to the Developer to decide on how much weightage needs to be given to the environmental aspects vis-à-vis traditional aspects of cost, quality and time. An environmentally committed Developer may consider giving more weightage to environmental aspects in the pre-qualification and in the actual awarding of the tender. They were also found to pressurize/coerce Contractors to implement green practices during the construction phase.

Also, some of the Developers were found to lead from the front by implementing green transportation practices such as use of video conferencing to reduce the carbon footprint of employee travel/transport. Further, they were also found to urge other stakeholders to reduce their transportation footprint which include both material and employee transport. Finally, like green design, the decision on the extent of end of life green practices was found to heavily depend on the decision made by the Developer. Given that green practices undertaken at the end of a buildings' useful life such as environmental friendly demolition, environmental friendly disposal, and segregation of demolition waste for re-use and recycling could save up to 30% of building's lifetime energy consumption (Blengini, 2009), the role of Developer is significant in minimizing the environmental impact of this phase. For instance, Developer could decide on

either a fast, unplanned demolition process where all the waste goes to landfill or carefully planned demolition process to maximise the recovery of recyclable materials.

Also, Developers could address some of the key barriers facing other stakeholders, namely tight and inflexible stakeholder deadlines and lack of stakeholder collaboration. This is because the project deadline is set up by the Developer. Developers, therefore, must give a more realistic timeframe for the stakeholders such as Architects/Consultants and Contractors to incorporate green practices (which typically takes longer to implement than conventional practices) in the supply chain. This could significantly improve the green performance of the projects. Similarly, Developers could play a part in minimizing lack of stakeholder collaboration in supply chains (which is intrinsic to the sector), because they have the power to decide the nature and extent of collaboration with other stakeholders given their superior position in the supply chain hierarchy. Also, they could monitor the relationships between other stakeholders in the supply chain and intervene if required to ensure all the commitment and collaboration of all stakeholders in greening the construction sector.

Finally, if more and more Developers initiate green projects, the other stakeholders will have no option but to comply with the green requirements of the Developers, as any failure to do so may lead to them not winning the project in the first instance, being expelled from the project or blacklisted from future projects. In summary, Developer emerged as the most important stakeholder in greening the construction sector.

Architects/Consultants

As mentioned earlier, the design stage is one of the most important phases in greening the construction supply chain. It is typically the Architects/Consultants who are responsible for the design stage in conjunction with the Developer. Skilfulness of the Architect/Consultant in providing a cost effective green design was found to reduce the environmental impact during construction, operational phase and end of life phase. For instance, considerations for modular design was found to enhance pre-fabrication during projects as well as easy disassembly during the building demolition to maximise recovery and recyclability of materials during building demolition. Also, Architects/Consultants was found to play a significant role in convincing the

Developers to go for green projects, especially to those Developers who are not aware of the environmental and financial benefits of implementing green practices.

Architects/Consultants is also responsible along with Developer for developing the tender specifications. Any oversight during the design or tender specifications was found to increase re-work and design changes at a later stage of the project leading to project being unsustainable. Further, the technical evaluation of the tender bid is conducted by the Architects/Consultants. The rigour in the evaluation of the tender bid of main Contractors including environmental aspects was found to contribute significantly in the environmental success of the project.

Further, like Developers, Architects/Consultants was also found to implement green transportation practices to reduce employee travel related emissions. They were also found to encourage other stakeholders to reduce transportation related emissions and thereby contributing to the reduction in the overall transportation emission in the supply chain. Also, the rigor in the Architects/Consultants monitoring of onsite-construction practices of Contractors was found to improve the onsite environmental practices of Contractors.

In addition, since the Architects/Consultants are responsible for approval of the material/product Suppliers in the project, most of them were found to use this authority to ensure environmentally unfriendly products such as products with hazardous materials and low recycled content are not approved. This to some extent have prompted Suppliers to manufacture and supply green materials/products. Moreover, given that they are also responsible for the final commissioning of the project, they were found to play an important role in ensuring the building meets the environmental requirements as specified in the tender and that non-compliance (if any) at this stage is reverted to the main Contractor to rectify before the building is commissioned. The stringency of the Architect/Consultant in the green building commissioning was found to ensure Contractors/Subcontractors and Suppliers are not bypassing any green requirements.

Moreover, any environmental related external training and auditing activities conducted by Architects/Consultants was found to improve their environmental practices and consequently the overall environmental performance of the supply chain.

Contractors/Subcontractors

Given that green construction practices on its own can contribute directly to more than 20% savings of a building's lifetime energy consumption (Ng et al., 2012), Contractors implementation of onsite green construction practices such as onsite waste segregation and recycling, use of energy efficient machineries and vehicles and use of pre-fabricated materials and materials with recycled content was found to play an important role in greening the construction sector. However, as mentioned earlier, in a typical construction project, the number of Contractors/Subcontractors can go up to hundreds if not thousands, and therefore ensure commitment and participation of all contracting firms is key to greening the sector. Though they typically do not play any direct role in the design stage, Contractors, as evidenced from the interviews, because of their vast onsite project experience could have contributed to green building design by suggesting design attributes that consume fewer materials and energy during construction. However, this is not the case in the construction sector. The sector, therefore, could benefit from early involvement of Contractors at the design stage.

Also, green purchasing practices of Contractors too was found to be equally important for improving the green performance of the sector. This is because their green purchasing activities involve environmental considerations in both material purchasing decisions and in the selection of Subcontractors. Moreover, in a typical construction project, hundreds if not thousands of purchase contracts are awarded by Contractors/Subcontractors. Therefore, stringency in the green purchasing decisions will have a significant impact on the environmental performance of the construction sector.

As evidenced from the study, equally important is the green transportation practices of Contractors/Subcontractors. This is because their transportation activities involve considerable material transport and employee transport. Given that green transportation activities alone could reduce roughly 6-8% of the life-cycle carbon emissions in construction projects (Ng et al., 2012), considerations made to reduce the environmental impacts of transportations such as providing employee accommodation near projects sites, transport of materials in full truck

quantities, use of energy efficient vehicles and use of video conferencing could significantly contribute in the environmental performance of the sector.

Finally, Contractors capability and keenness to execute environmentally friendly demolition projects was found to significantly improve the end of life green practices such as reducing the impact on the surrounding flora and fauna, potential noise, and soil and water pollution of nearby sources. Most importantly, given that end of life green practices has the potential to save up to 50% of the embodied energy in materials/products (Yan et al., 2010), the skilfulness of Contractor in the demolition activities was found to have a significant impact on the overall environmental performance of the sector. Also, the environmental training and auditing activities conducted by the Contractors was also found to improve the green practices of Subcontractors and Suppliers.

Suppliers

Given that up to 10% of the global energy is consumed for the manufacturing of the construction materials/products, Suppliers play a key role in greening the construction sector. For instance, the green product design aspects considered by Suppliers such as product with high recycled content and low embodied energy and reduction/elimination of hazardous materials was found to reduce the overall embodied/life-cycle energy consumption of the building. Also, the design consideration of Suppliers was found to enhance the recyclability/recoverability of the material/product during the end of life demolition. Although their involvement in the construction project was found to be at the later stage, evidence from this study shows that if they are involved at the early stage, they could understand the design requirements much better and could, therefore, provide customized product to meet the design challenges. Also, better green product design by Suppliers was found to enhance the constructability of Contractors.

The environmental considerations made during purchasing of raw materials such as raw materials with low embodied energy, raw materials that require less treatment and processing, along with other green purchasing practices such as electronic invoicing, and purchasing of raw materials from proximity was found to improve the environmental performance of the sector.

Green manufacturing was found to be one of the important green practices of Suppliers that have contributed to the environmental performance of the sector. Most of the Suppliers

considered in this study were found to have state-of-the-art green manufacturing facilities that significantly improves the environmental performance of manufacturing such as reduction in carbon emissions, energy and water consumption. In fact, one of the glass manufacturer interviewed in this study was found to reduce its carbon emissions by 60% and energy consumption by 30%. Like Contractors, green transportation practices such as full truckload transportation and careful selection of delivery schedule to avoid traffic congestion was found to improve the environmental performance of the sector.

Further, green-related R&D was found to be the highest among Suppliers and therefore is contributing significantly to the development of innovative green products to minimize the environmental impacts of the sector. However, collaborative research and development between Suppliers and other stakeholders, which is common in other sectors, is relatively low in the construction sector. The construction sector, therefore, could benefit in the future from collaborative research and development.

Also, the significant internal drive of Suppliers such as their environmental commitment, to reduce costs and enter foreign markets is helping the sector develop new and innovative green products. Also, Suppliers could play a direct role minimizing some of the key barriers facing the sector such as high cost of green projects and lack of local green material Suppliers. This is because material cost itself can reach a value of as much as 50-60% of the total cost of the project (Stuckhart, 1995). Therefore, if Suppliers can continuously reduce the cost of green products, it will encourage more and more Developers to consider green projects, which in turn will improve the environmental performance of the sector. Likewise, encouraging or providing support for local Suppliers to develop green products will lead to more Developers and Contractors to consider green practices in their projects.

11.4. Research contributions

While several individual contributions of this study are discussed throughout the thesis as well as during the discussion on research questions in the previous section, here some of the main research contributions of this study towards theory, for policymakers and practitioners are presented.

Contributions to Theory

The study is arguably the first comprehensive attempt to understand GSCM and its importance/relevance in greening the construction sector. To conceptualise the multifaceted reality of GSCM, the study provides several validated first-order constructs, namely external and internal drivers, external and internal barriers, facilitating green practices, environmental, economic/cost and organisational performance, and a robust second-order construct, core green practices, underlying the following first-order constructs: green design, green purchasing, green transportation, green construction/manufacturing and end of life green practices. This itself is a significant theoretical contribution given that construct development and validation is at the heart of theory building. The study also provides three validated models, namely GSCM driver-barrier-practice model (Figure 3.4), GSCM practice-performance model (Figure 3.5), and facilitating-core green practices model (Figure 3.6) to conceptualize the complex GSCM relationships between constructs. Finally, the study proposes a comprehensive GSCM framework (refer Appendix 5) integrating these three models. Future researchers could use/adapt this GSCM framework in their respective settings in construction or other sectors. A comprehensive and validated GSCM framework of this depth and breadth have not been identified previously in any sector let alone construction sector and therefore contributes significantly to the theoretical advancement of the field.

In addition, at the construct level, the study has identified several novel factors within the constructs. For instance, green drivers such as competitor pressure and buyer/end-consumer pressure have not been discussed previously in the construction literature and therefore add to the novelty of this study. Similarly, tight and inflexible stakeholder deadline emerged as a novel barrier in the construction sector. In fact, tight and inflexible stakeholder deadline as a barrier has not been identified previously in any sector let alone construction and therefore adds to the generic GSCM literature.

In terms of green practices, the study provides a detailed understanding on each of the core and facilitating green practices, particularly practices such as green transportation, end of life green practices, cross-functional integration and green-related research and development, which has

seen limited research previously in the green/sustainability literature in construction sector, and therefore significantly adds to the novelty of this study. Also, among the findings, green-related research and development as a facilitating/supporting green practice has not been identified previously in any sector let alone construction and hence makes a novel contribution to the generic GSCM literature.

With regards to green performance, the study, in general, addresses the lack of application of performance measures as well as the lack of consistency in the use of performance measures including environmental and cost/economic performance in the construction sector. Moreover, the application of organisational performance such as an increase in sales, profits and market share to capture the long-term benefits of green practices has not been undertaken previously in the construction literature and therefore adds to the novelty.

Further, one-to-one mapping conducted in this study to get an in-depth understanding of the relationship between green drivers, barriers and practices, between green practices and performance, and between facilitating and core green practices at the factor level has not been undertaken previously in the construction sector and hence constitutes a novelty.

The other significant contribution of this study is that it addresses the lack of theoretically grounded research in GSCM in the construction sector. This study uses the application of several established and emerging theories in the conceptualisation of the multifaceted reality of GSCM. Since the accumulation of empirical evidence is of limited value unless accompanied by sound theoretical principles, which are fundamental for decision-making and managerial actions, the theoretical underpinnings of this study are expected to provide practitioners and/or policymakers faced with the reality of addressing complex sustainability challenges with a deeper, broader and more simplified conceptualization of GSCM perspectives beyond the individual issues in the supply chain.

Finally, for the generic GSCM literature, the study addresses the lack of consensus on its definition and scope. The study could be considered as a first comprehensive step towards the precise identification of a coherent conceptual base for the GSCM field to grow as a legitimate management discipline not only in construction but also in general.

Contributions for Policymakers

The study provides an exceptional opportunity for policymakers to comprehend the underlying differences in green drivers, barriers, practices, and performance and their relationships across each stakeholder, so that any (informed) stakeholder specific policy changes/interventions and actions can be taken to improve the greening efforts of stakeholders, especially those who are lagging behind the others.

The study also reaffirms the importance of government in not only changing the status quo of the construction sector in embracing green practices but also in taking a more active role in promoting green practices across stakeholders. For instance, the heterogeneity in the influence of green drivers on green practices across different stakeholders and firm categories (based on size and ownership) shows that there are several opportunities for the sector to leverage from green drivers. For example, policymakers may decide on imposing more stringent green regulations specific for large firms, since they consider the current regulations less onerous to fulfil. Similarly, as evidenced by the interviews, the government could consider empowering NGOs, which at present have limited influence in driving green practices in the sector. Also, a concerted effort is required from government side in hosting conferences, workshops and seminars in increasing the buyer/investor green awareness, which at present is low in the UAE.

Likewise, in terms of green barriers, government, must strive to support stakeholders and firm types (based on size and ownership), especially those who are lagging behind, in overcoming barriers, both at the sector level and at the firm level. This also implies that, before enacting any mandatory green regulations, the government should take into consideration the constraints facing firms, especially SMFs and local firms, as they may not keep up with the regulations and may lead them to go out of business. The insights from the study also call on the government to provide incentives/subsidies for these firms to implement green practices as well as provide preferential treatment for environmentally committed firms in government projects or awards.

The other concern for policymakers is that the current green building regulation is mainly targeted at the Developer and Contractors. Policymakers should also consider Architects/Consultants and Suppliers as part of green building regulations as both of the

stakeholders play an equally important role in greening the sector. For instance, the government could consider making the green material, product, and system certification mandatory, which would not only ensure the effective performance of the Suppliers but also bring more green Suppliers to the country, which would eventually reduce the costs.

The other concern emerged from the study, which the government need to address, is the fact that there is no federal-level green building regulation in the UAE as different emirates, such as Dubai and Abu Dhabi, and free zones have different green building regulations. The sector could significantly benefit from unified federal green building regulations instead of having multiple green building regulations.

Further, the relatively low extent of green practices' implementation of SMFs vis-à-vis large firms and local firms vis-à-vis foreign firms is a major concern for policymakers, especially given the sheer number of SMFs and local firms. Policymakers, therefore, need to coherently work towards improving the green practices of SMFs and local firms. Concerned authorities must also strive to create a diffusion mechanism (flow of green-related knowledge, skills and expertise) from large firms to SMFs and from foreign firms to local firms to improve the green practices of SMFs and local firms. This could be through collaborative partnerships and mentoring opportunities with large firms and foreign firms and/or through large firms and foreign firms pressurizing SMFs and local firms to implement green practices.

Also, the use of performance measures to capture and report green performance (environmental, cost/economic and organisational) are not mandatory at present in the UAE construction sector. The government could consider making the use and reporting of all three standardised performance measures (similar to the measures identified in this study) mandatory for relevant stakeholders in the UAE. Finally, the government should strive to attract more foreign firms to the UAE as they not only have a more positive attitude towards sustainability but who are making a concerted effort to educate the market on the benefits of green practices.

Contributions for Practitioners

The study provides practitioners (across all stakeholders) with a potential stock of core and facilitating green practices that they could implement in greening the construction supply chain.

This knowledge is important for the construction sector because previously practitioners across each stakeholder had limited understanding regarding the nature and details of different core and facilitating green practices they could have implemented in their respective firms. This includes simple green practices such as the use of video conferencing instead of face to face meeting (within green transportation) to complex green practices such as the use of energy efficient machinery in onsite construction. This implies that firms with limited knowledge and resource constraints can start by implementing simple green practices and then gradually move towards more complex green practices.

Also, the study provides practitioners with a simple, standardised, easy to operationalise performance measures to capture the green performance. The study also provides practitioners with an opportunity to gauge the green drivers and barriers affecting their green practices implementation, both at the construct level and at the factor level. The knowledge of these relationships is important for practitioners to devise strategies to effectively maximise/leverage the drivers and minimise/eliminate the barriers to promoting efficient and effective green practices implementation. Further, the positive impact of green practices on all three aspects of performance across stakeholders shows that “being green pays” both in the short run and in the long run. These significant “win-win” opportunities are particularly encouraging for SMFs and local firms (who are doubtful about the benefits of green practices) as they are not far behind large firms and foreign firms respectively, in any of the green performance aspects. This should, therefore, provide impetus from an environmental and business perspective for the thousands of SMFs and local firms in the UAE and elsewhere to implement green practices.

Further, the construct level and factor level understanding on the relationships between green practices and green performance could be used by practitioners to prioritise the implementation of those individual facilitating and/or core green practices in line with the firm’s targeted green performance goals (taking all three performance aspects into consideration). For instance, firms could choose strategically to decide on improving all three performance aspects or settle for trade-offs. Furthermore, the finding of the impact of facilitating green practices on core green practices shows that facilitating practices is a necessary precursor to the implementation of core

green practices and therefore should provide the impetus for firms to make a prioritised investment in facilitating practices to improve their core green practices.

11.4. Limitations and suggestions for future research

Although this thesis carried out a comprehensive GSCM investigation in the construction sector, the thesis still had several limitations, which are summarised as follows:

- The construction sector considered in the study includes only the build sector (residential and non-residential buildings). The general construction sector also includes the civil engineering sector that is responsible for the construction of motorways, streets, bridges, tunnels, sewerage systems, etc. (ISIC Rev 4, 2012). Future studies could also consider the civil engineering sector in their investigation.
- The study may not have covered every facet of GSCM. For instance, there could be additional (unknown) country-specific aspects that may not have emerged in our exploratory interviews. Also, some aspects which are not relevant to the UAE that were excluded from the analysis could be of interest in other country settings. For example, pressure from NGOs, which was excluded from this study because of its non-relevance to the UAE, could be an important driver in another setting.
- The GSCM themes/sub-themes (constructs) proposed in this study may require further refinement and validation across different countries.
- The study also faced the issue of a small sample size, because of which it was not possible to run the full-fledged structural equation modelling of the full GSCM framework (refer Appendix 9.1). Instead, the study had to be content with independently assessing three models (Figure 3.4, 3.5 and 3.6). Future studies with large-scale data could attempt to validate the full GSCM framework.
- The use of perceptual measures because of the lack of availability of published performance data for environmental, economic, and organisational performance can be considered as a limitation. If the data becomes available, future research can focus on using actual and preferably more objective data on performance.
- The theories presented here are by no means exhaustive and could be biased based on the author's familiarity and disposition.

- The operational phase of the building is not considered within the scope of this paper, since environmental consideration made during the design stage (green design) largely determines the environmental impacts during the operational phase of building. However, the real performance during the operational phase could be much lower than the intended during the design stage. Hence, a more focused investigation may be required for the operational phase.
- The impact of firm size on GSCM was understood by controlling the impact of firm ownership, and similarly, the impact of firm ownership on GSCM was understood by controlling the impact of firm size. This can be considered as a limitation, as it does not capture the impact of both together such as large foreign vs. large local or small foreign vs large local. Future studies could investigate the combined impact of both size and ownership on GSCM.
- Future researchers could utilise this theoretical understanding either directly in their research contexts or as a basis for cumulative theory building and testing. This is important, as theory building and testing is an ongoing process, and can only be strengthened through a series of further refinement and tests across different populations and settings.
- Researchers in the future could utilise the multimethodology pragmatic approach used in this thesis for conducting a comprehensive investigation in the respective settings in construction or other sectors. Also, researchers could utilise the pre-tested and validated survey instrument for empirical investigation in their respective settings.

Despite the limitations, in light of the findings of this comprehensive investigation along with its contribution, a heightened interest among construction firms, practitioners and policymakers in the application of GSCM in the construction sector can be foreseen. Also, the study is expected to generate significant interest within the research community that could further lead to the theoretical advancement of GSCM in the construction sector and in general.

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Appendices

Appendix A - Interview Protocol (Phase 1 Interviews)

Main questions

- What are the green practices implemented by the sector in general?
- What specific green practices do you implement in your firm? And why?
- What are the external forces that is driving the sector in general to implement green practices?
- What are the specific external factors that is driving your firm to implement these green practices?
- What internally motivates firms in general to implement green practices in the sector?
- What motivates your firm internally to implementing these green practices?
- What external challenges are stopping the sector in general from implementing green practices?
- What are specific external challenges that is stopping your firm from implementing green practices?
- What are the internal challenges firms facing in general to implement green practices in the sector?
- What are the challenges that you face internally in implementing these green practices?
- Does your firm use any environmental performance measures to assess the benefits of those green practices implemented in your firm? If so, why these measures? (if not, why not use measures?)
- In your opinion, what are the important environmental performance measures to assess the benefits of green practices in general for the sector?
- Do you see any overall improvement in environmental performance, a while after the implementation of green practices? If so, to what extent and why? (If not why?)
- Does your firm use any cost/economic performance measures to assess the overall cost implications of those green practices implemented in your firm? If so, why these measures? (if not, why not use measures?)
- In your opinion, what are the important cost/economic performance measures to assess the cost implications of green practices in general for the sector?
- Do you see any improvement in cost/economic performance, a while after the implementation of green practices? If so, to what extent and why? (If not why?)

- Does your firm use any organizational performance measures to assess the overall long term benefits of those green practices implemented in your firm? If so, why these measures? (if not, why not use measures?)
- In your opinion, what are the important organizational performance measures to assess the long-term benefits of green practices in general for the sector?
- Do you see or foresee any long-term improvement in organizational performance after the implementation of green practices? If so, to what extent and why? (If not why?)

Appendix B - Interview Protocol (Phase 2 Interviews)

Main questions

- What are the green practices implemented by your firm? and to what extent do you implement these green practices?
- How do and to what extent each of these green practices impact the implementation of other green practices? (for example, to what extent EMS impact the implementation of green design?)
- What external factors drives your firm in implementing these green practices? How do you rate the importance/strength of each of these external pressures in terms of their ability in driving each of the mentioned green practices? (for example, to what extent government regulation impacted your green design practices?)
- What factors drives your firm internally in implementing these green practices? How do you rate the importance/strength of these internal pressures/motives in terms of their ability in driving each of the mentioned green practices? (for example, to what extent your desire to reduce cost impacted your green design practices?)
- What are the external barriers/challenges facing your firm in implementing these green practices? How do you rate the importance/strength of each of these external barriers in preventing your firm from implementing each of the mentioned green practices? (for example, to what extent lack of green professionals impacted your green design practices?)
- What are the internal barriers/challenges facing your firm in implementing these green practices? How do you rate the importance/strength of each of these internal barriers in preventing your firm from implementing each of the mentioned green practices? (for example, to what extent lack of green professionals impacted your green design practices?)
- To what extent has each of these mentioned green practices impacted your environmental performance? (for example, to what extent green design improved your environmental performance?)
- To what extent has each of these green practices impacted your economic/cost performance? (for example, to what extent green design improved your economic/cost performance?)
- To what extent has each of these green practices impacted your organizational performance? (for example, to what extent green design improved your organizational performance?)

Appendix C – Survey Questionnaire

"Implementation of Green/Environmental Practices in the UAE Construction Sector"

The survey below seeks to assess the implementation of different green/environmental practices within the UAE construction sector including the underlying motives, challenges faced and benefits derived from their implementation. We kindly request you to participate in this survey which will take not more than 10-15 minutes of your time but could significantly contribute towards greening of this sector. Any information collected through this survey will be aggregated to maintain confidentiality and prevent the identification of specific respondents. Individual data will not be made available to third parties under any condition.

The study is conducted in accordance with Middlesex University Ethical Code of Practice for Research (for further information, please refer: http://unihub.mdx.ac.uk/study/research_Ethics/index.aspx).

Thank you for your interest and participation in this study.

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Should you have any questions relating to this survey, please feel free to contact us.

Q1 Primary role of your organization in construction? **(Branching question)**

- . Developer (1)
- . Architect (2)
- . Consultant (3)
- . Contractor (4)
- . Supplier of construction materials (eg: Supplier of Steel, Aluminium, Glass, Ceramics, Cement/Concrete, Chemicals, HVAC systems, Machineries etc.) (5)

Q2 The number of employees in your organization are?

- . Less than 50 (1)
- . 51-100 (2)
- . 101-250 (3)
- . 251-500 (4)
- . Greater than 500 (5)

Q3 Your organization is owned by?

- . Majority ownership with local UAE business groups/entrepreneurs (1)
- . Majority ownership with UAE government (2)
- . Majority ownership with foreign multinationals (3)
- . I don't know (4)

If Developer is Selected in Q1:

Q4 Green/environmental practices in your organization

Please respond in relation to your organization	Strongly Agree (5)	Agree (4)	Neither Agree nor Disagree (3)	Disagree (2)	Strongly Disagree (1)	Not aware/ Not applicable
Formal policies, procedures and systems are used for implementing green/environmental practices						
International environmental certifications such as ISO 14001 have been obtained						
Cross functional teams from different departments are used when implementing green/environmental practices						
Training is imparted to employees on green/environmental issues						
Projects are audited from a green/environmental perspective						
Research and development (R&D) is done to improve green/environmental practices						
Environmental impact assessment of design is done						
Natural ventilation is considered in projects						
Natural lighting is considered in projects						
Waste water recycling is considered in projects						
Photo-voltaic panels is considered in projects						
Energy efficient lighting system is considered in projects						
Energy efficient heating and air conditioning (HVAC) systems is considered in projects						
Pre-fabricated components are considered in projects						
Materials with high re-cycled content and low embodied energy is considered in projects						
Non-hazardous materials are considered in projects						
Environmental criteria(s) are included in material purchase decisions						
Environmental criteria(s) are included in tendering						
To reduce transportation and associated emissions, provision of accommodation to employees near project sites is considered						
To reduce transportation and associated emissions, use of video conferencing in place of face to face meetings is considered						
To reduce transportation and associated emissions, employees are encouraged to use shared transport and public transport						
Environmental impact is considered at the time of end of life demolition of projects						
Material from the end of life demolished projects is recycled						

Q5. Please rate the extent to which following factors have influenced your organization's drive to implement green/environmental practices

	Extremely high influence (5)	High influence (4)	Moderate Influence (3)	Little Influence (2)	No Influence (1)	Not aware / Not applicable (0)
Government green-related regulations						
Pressure from supply chain partners						
Pressure from competitors						
Pressure from buyers/end customers						
Commitment to protecting the environment						
Enhance green reputation/brand image						
To reduce costs						
To access foreign markets that is having stringent green/environmental requirements						

Q6. Please rate the extent to which each of the following factors have acted as a barrier/challenge in implementing green/environmental practices in your organization

	Extremely high (5)	High (4)	Moderate (3)	Low (2)	Not at all (1)	Not aware / Not applicable
Non-availability of local professionals having knowledge of green/environmental practices						
Non-availability of local suppliers of green/environmentally friendly materials						
Tight and inflexible project deadlines (which provide little time for planning and implementing green/environmental practices)						
Lack of willingness from stakeholders to collaborate to implement green/environmental practices						
High cost of implementation						
Lack of knowledge and awareness of green/environmental practices within the organization						

Q7 Please indicate the extent of improvement in performance from implementing green/environmental practices in your organization.

	Strongly Agree (5)	Agree (4)	Neither Agree nor Disagree (3)	Disagree (2)	Strongly Disagree (1)	Not aware/ Not applicable
Greenhouse gas emissions have decreased						
Water consumption has decreased						
Energy consumption has decreased						
Landfill waste has decreased						
Material use has decreased						
Hazardous material use has decreased						
Number of environmental accidents has declined						
Material expenses per unit constructed area has decreased						
Total environmental penalties and fines per unit constructed area has decreased						
Because of green/environmental practices being used, more number of projects were sold						
Because of green/environmental practices being used, projects were sold at a higher price						
Because of green/environmental practices being used, market share among UAE competitors has increased						
Because of green/environmental practices being used, return on investment has increased						
Because of green/environmental practices being used, profits have increased						

If Architect/Consultant is Selected in Q1:

Q4 Green/environmental practices in your organization

Please respond in relation to your organization	Strongly Agree (5)	Agree (4)	Neither Agree nor Disagree (3)	Disagree (2)	Strongly Disagree (1)	Not aware/ Not applicable
Formal policies, procedures and systems are used for implementing green/environmental practices						
International environmental certifications such as ISO 14001 have been obtained						
Cross functional teams from different departments are used when implementing green/environmental practices						
Training is imparted to employees on green/environmental issues						
Projects are audited from a green/environmental perspective						
Research and development (R&D) is done to improve green/environmental practices						
Environmental impact assessment of projects is done						
Provision for natural ventilation is considered in projects						
Provision for natural lighting is considered in projects						
Provision for waste water recycling is considered in projects						
Use of photo-voltaic panels is considered in projects						
Use of energy efficient lighting system is considered in projects						
Use of energy efficient heating and air conditioning (HVAC) systems is considered in projects						
Use of pre-fabricated components is considered in projects						
Use of materials with high re-cycled content and low embodied energy is considered in projects						
Reducing use of hazardous materials is considered in projects						
To reduce transportation and associated emissions, provision of accommodation to employees near project sites is considered						
To reduce transportation and associated emissions, use of video conferencing in place of face to face meetings is considered						
To reduce transportation and associated emissions, employees are encouraged to use shared transport and public transport						
Environmental impact is considered at the time of end of life demolition of projects						
Material from the end of life demolished projects is recycled						

Q5. Please rate the extent to which following factors have influenced your organization's drive to implement green/environmental practices

	Extremely high influence (5)	High influence (4)	Moderate influence (3)	Little influence (2)	No influence (1)	Not aware / Not applicable (0)
Government green-related regulations						
Pressure from supply chain partners						
Pressure from competitors						
Commitment to protecting the environment						
Enhance green reputation/brand image						
To access foreign markets that is having stringent green/environmental requirements						

Q6. Please rate the extent to which each of the following factors have acted as a barrier/challenge in implementing green/environmental practices in your organization

	Extremely high (5)	High (4)	Moderate (3)	Low (2)	Not at all (1)	Not aware / Not applicable
Non-availability of local professionals having knowledge of green/environmental practices						
Non-availability of local suppliers of green/environmentally friendly materials						
Tight and inflexible project deadlines (which provide little time for planning and implementing green/environmental practices)						
Lack of willingness from stakeholders to collaborate to implement green/environmental practices						
High cost of implementation						
Lack of knowledge and awareness of green/environmental practices within the organization						

Q7 Please indicate the extent of improvement in performance from implementing green/environmental practices in your organization.

	Strongly Agree (5)	Agree (4)	Neither Agree nor Disagree (3)	Disagree (2)	Strongly Disagree (1)	Not aware/ Not applicable
Greenhouse gas emissions have decreased						
Water consumption has decreased						
Energy consumption has decreased						
Landfill waste has decreased						
Material use has decreased						
Hazardous material use has decreased						
Number of environmental accidents has declined						
Because of green/environmental practices being used, more project orders are received						
Because of green/environmental practices being used, orders are received at a higher price						
Because of green/environmental practices being used, market share among UAE competitors has increased						
Because of green/environmental practices being used, return on investment has increased						
Because of green/environmental practices being used, profits have increased						

If Contractor is Selected in Q1:

Q4 Green/environmental practices in your organization

Please respond in relation to your organization	Strongly Agree (5)	Agree (4)	Neither Agree nor Disagree (3)	Disagree (2)	Strongly Disagree (1)	Not aware/ Not applicable
Formal policies, procedures and systems are used for implementing green/environmental practices						
International environmental certifications such as ISO 14001 have been obtained						
Cross functional teams from different departments are used when implementing green/environmental practices						
Training is imparted to employees on green/environmental issues						
Projects are audited from a green/environmental perspective						
Research and development (R&D) is done to improve green/environmental practices						
Environmental criteria(s) are included in material purchase decisions						
Environmental criteria(s) are included in tendering						
To reduce transportation and associated emissions, provision of accommodation to employees near project sites is considered						
To reduce transportation and associated emissions, use of video conferencing in place of face to face meetings is considered						
To reduce transportation and associated emissions, employees are encouraged to use shared transport and public transport						
To reduce transportation and associated emissions, materials are transported in full truck load quantities						
To reduce transportation and associated emissions, materials are transported in fuel efficient vehicles						
To reduce emission at project sites, fuel efficient machinery is used						
Comprehensive waste management plan is developed for project sites						
To reduce manual waste, automation is used for onsite construction activities (concrete mixers, spreaders etc.)						
Provision for waste water recycling is available at project site						
Pre-fabricated components are used at projects						
Materials with high re-cycled content and low embodied energy is used						
Non-hazardous materials are used in projects						
Environmental impact is considered at the time of end of life demolition of projects						
Material from the end of life demolished projects is recycled						

Q5. Please rate the extent to which following factors have influenced your organization's drive to implement green/environmental practices

	Extremely high influence (5)	High influence (4)	Moderate Influence (3)	Little Influence (2)	No Influence (1)	Not aware / Not applicable
Government green-related regulations						
Pressure from supply chain partners						
Pressure from competitors						
Commitment to protecting the environment						
Enhance green reputation/brand image						
To reduce costs						
To access foreign markets that is having stringent green/environmental requirements						

Q6. Please rate the extent to which each of the following factors have acted as a barrier/challenge in implementing green/environmental practices in your organization

	Extremely high (5)	High (4)	Moderate (3)	Low (2)	Not at all (1)	Not aware / Not applicable
Non-availability of local professionals having knowledge of green/environmental practices						
Non-availability of local suppliers of green/environmentally friendly materials						
Tight and inflexible project deadlines (which provide little time for planning and implementing green/environmental practices)						
Lack of willingness from stakeholders to collaborate to implement green/environmental practices						
High cost of implementation						
Lack of knowledge and awareness of green/environmental practices within the organization						

Q7 Please indicate the extent of improvement in performance from implementing green/environmental practices in your organization.

	Strongly Agree (5)	Agree (4)	Neither Agree nor Disagree (3)	Disagree (2)	Strongly Disagree (1)	Not aware/ Not applicable
Greenhouse gas emissions have decreased						
Water consumption has decreased						
Energy consumption has decreased						
Landfill waste has decreased						
Material use has decreased						
Hazardous material use has decreased						
Number of environmental accidents has declined						
Material expenses per unit constructed area has decreased						
Water expenses per unit constructed area has decreased						
Energy expenses per unit constructed area has decreased						
Cost of managing waste per unit constructed area has decreased						
Total environmental penalties and fines per unit constructed area has decreased						
Because of green/environmental practices being used, more project orders were received						
Because of green/environmental practices being used, orders are received at a higher price						
Because of green/environmental practices being used, market share among UAE competitors has increased						
Because of green/environmental practices being used, return on investment has increased						
Because of green/environmental practices being used, profits have increased						

If Supplier is Selected:

Q4 Green/environmental practices in your organization

Please respond in relation to your organization	Strongly Agree (5)	Agree (4)	Neither Agree nor Disagree (3)	Disagree (2)	Strongly Disagree (1)	Not aware/ Not applicable
Formal policies, procedures and systems are used for implementing green/environmental practices						
International environmental certifications such as ISO 14001 have been obtained						
Cross functional teams from different departments are used when implementing green/environmental practices						
Training is imparted to employees on green/environmental issues						
Projects are audited from a green/environmental perspective						
Research and development (R&D) is done to improve green/environmental practices						
Environmental criteria(s) are included in material purchase decisions						
Environmental criteria(s) are included in tendering						
Raw materials with high re-cycled content and low embodied energy is considered during design						
Non-hazardous materials are considered during design						
Environmental criteria(s) are included in all purchase decisions						
Environmental criteria(s) are included in all tendering						
To reduce transportation and associated emissions, use of video conferencing in place of face to face meetings is considered						
To reduce transportation and associated emissions, employees are encouraged to use shared transport and public transport						
To reduce transportation and associated emissions, materials are transported in full truck load quantities						
To reduce transportation and associated emissions, materials are transported in fuel efficient vehicles						
To reduce emission during manufacturing process, fuel/energy efficient machineries are used						
Comprehensive waste management plan is developed for the manufacturing process						
To reduce manual waste, automation is used in the manufacturing process						
Provision for waste water recycling is available at manufacturing site						

Q5. Please rate the extent to which following factors have influenced your organization's drive to implement green/environmental practices

	Extremely high influence (5)	High influence (4)	Moderate Influence (3)	Little Influence (2)	No Influence (1)	Not aware / Not applicable (0)
Pressure from supply chain partners						
Pressure from competitors						
Commitment to protecting the environment						
Enhance green reputation/brand image						
To reduce costs						
To access foreign markets that is having stringent green/environmental requirements						

Q6. Please rate the extent to which each of the following factors have acted as a barrier/challenge in implementing green/environmental practices in your organization

	Extremely high (5)	High (4)	Moderate (3)	Low (2)	Not at all (1)	Not aware / Not applicable
Non-availability of local professionals having knowledge of green/environmental practices						
Non-availability of local suppliers of green/environmentally friendly materials						
Tight and inflexible project deadlines (which provide little time for planning and implementing green/environmental practices)						
Lack of willingness from stakeholders to collaborate to implement green/environmental practices						
High cost of implementation						
Lack of knowledge and awareness of green/environmental practices within the organization						

Q7 Please indicate the extent of improvement in performance from implementing green/environmental practices in your organization.

	Strongly Agree (5)	Agree (4)	Neither Agree nor Disagree (3)	Disagree (2)	Strongly Disagree (1)	Not aware/ Not applicable
Greenhouse gas emissions have decreased						
Water consumption has decreased						
Energy consumption has decreased						
Landfill waste has decreased						
Material use has decreased						
Hazardous material use has decreased						
Number of environmental accidents has declined						
Material expenses per unit constructed area has decreased						
Water expenses per unit constructed area has decreased						
Energy expenses per unit constructed area has decreased						
Cost of managing waste per unit constructed area has decreased						
Total environmental penalties and fines per unit constructed area has decreased						
Because of green/environmental practices being used, more project orders were received						
Because of green/environmental practices being used, orders are received at a higher price						
Because of green/environmental practices being used, market share among UAE competitors has increased						
Because of green/environmental practices being used, return on investment has increased						
Because of green/environmental practices being used, profits have increased						

Q8 Your organization has been operating for?

- . Less than 5 years (1)
- . 5 to 15 years (2)
- . Greater than 15 years (3)
- . I don't know (4)

Q9 Your designation/role in the organization is?

Q10 The total number of years that you have been working in the construction sector is?

- . 0-2 years (1)
- . 2 to 5 years (2)
- . 5 to 10 years (3)
- . Greater than 10 years (4)

Q11 The number of years that you have been working in the present organization is?

- . 0-2 years (1)
- . 2 to 5 years (2)
- . 5 to 10 years (3)
- . Greater than 10 years (4)

Q12 How would you rate your knowledge and understanding of green/environmental issues pertaining to the construction sector is?

- . None at all (1)
- . Little (2)
- . Average (3)
- . Much (4)
- . To a great extent (5)

Q13 Your level of involvement in green/environmental related activities in your organization is?

- . None at all (1)
- . Little (2)
- . Average (3)
- . Much (4)
- . To a great extent (5)

Q14 Please provide your comments/suggestions in general or regarding the survey

Thank you for your time

Appendix D – First order confirmatory factor loadings of constructs

	Standardized Confirmatory Factor Loading			
	Developer	Architect/ Consultant	Contractor	Supplier
External drivers				
Extdrv_1	0.875	0.865	0.763	0.209
Extdrv_2	0.749	0.807	0.842	0.968
Extdrv_3	0.858	0.908	0.863	0.938
Extdrv_4 ^a	0.415	-	-	
Internal drivers				
Intdrv_1	0.617	0.860	0.895	0.716
Intdrv_2	0.598	0.891	0.916	0.852
Intdrv_3	0.926	0.845	0.876	0.217
Intdrv_4	0.703	0.887	0.886	0.686
External barriers				
Extbar_1	0.558	0.802	0.801	0.812
Extbar_2	0.417	0.700	0.795	0.519
Extbar_3	0.873	0.708	0.707	0.925
Extbar_4	0.718	0.786	0.813	0.857
Internal barriers				
Intbar_1	0.858	0.539	0.840	0.521
Intbar_2	0.861	0.835	0.773	0.903
Facilitating green practices				
Fcltgp_1	0.830	0.753	0.533	0.352
Fcltgp_2	0.846	0.485	0.769	0.772
Fcltgp_3	0.663	0.898	0.797	0.842
Fcltgp_4	0.938	0.696	0.680	0.339
Fcltgp_5	0.876	0.886	0.675	0.989
Green design^b				
Grdsgn_1	0.451	0.799	-	-
Grdsgn_2	0.286	0.656	-	-
Grdsgn_3	0.568	0.798	-	-
Grdsgn_4	0.477	0.658	-	-
Grdsgn_5	0.842	0.817	-	-
Grdsgn_6	0.829	0.702	-	-
Grdsgn_7	0.782	0.762	-	-
Grdsgn_8	0.907	0.601	-	-
Grdsgn_9	0.790	0.883	-	0.780
Grdsgn_10	0.394	0.686	-	0.789
Green purchasing				
Grpurc_1	0.947	0.906	0.939	0.819
Grpurc_12	0.918	0.871	0.974	0.824

**shaded cells indicate factor loadings less than 0.5; ^aindicate the item only relevant to Developer; ^bindicate construct only relevant to Developer and Architect/Consultant; ^cindicate item not relevant for supplier; ^dindicate item not relevant for Developer and Architect/Consultant, ^eindicate green construction is relevant for contractor and corresponding practice for supplier is green manufacturing, ^findicates items only relevant to contractors*

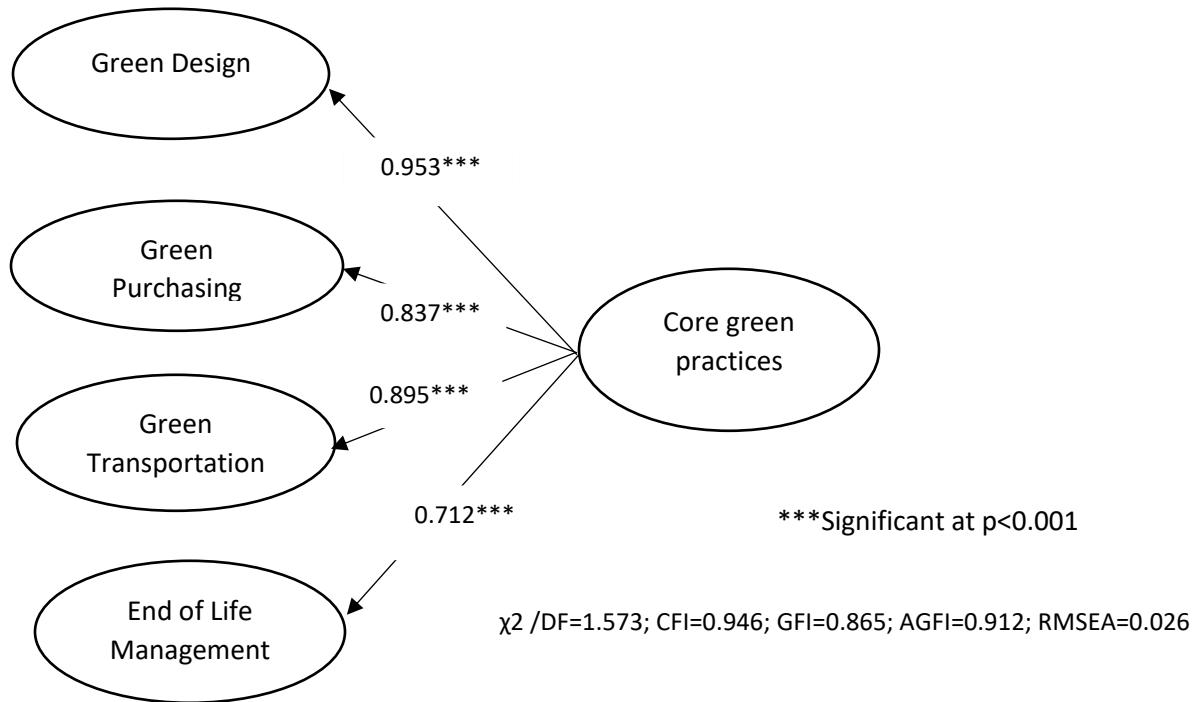
Appendix D – First order confirmatory factor loadings of constructs (continued)

	Standardized Confirmatory Factor Loading			
	Developer	Architect/ Consultant	Contractor	Supplier
Green transportation				
Grtran_1 ^c	0.964	0.803	0.822	-
Grtran_2	0.921	0.901	0.849	0.237
Grtran_3	0.888	0.873	0.852	0.984
Grtran_4 ^d	-	-	0.832	0.868
Grtran_5 ^d	-	-	0.884	0.944
Green construction /manufacturing^e				
Grncon_1/grnman_1	-	-	0.674	0.946
Grncon_2 ^f	-	-	0.726	-
Grncon_3 ^f	-	-	0.840	-
Grncon_4 ^f	-	-	0.739	-
Grncon_5/grnman_2	-	-	0.800	0.828
Grncon_6/grnman_3	-	-	0.788	0.654
Grncon_7/grnman_4	-	-	0.787	0.946
End of life management				
Endmgt_1	0.986	0.882	0.865	0.571
Endmgt_2	0.968	0.928	0.798	0.868
Environmental performance				
Envper_1	0.678	0.747	0.620	0.912
Envper_2	0.934	0.891	0.686	0.859
Envper_3	0.681	0.838	0.760	0.870
Envper_4	0.739	0.834	0.768	0.942
Envper_5	0.955	0.854	0.772	0.745
Envper_6	0.907	0.728	0.595	0.698
Envper_7	0.635	0.792	0.660	0.870
Economic/cost performance				
Ecooper_1	0.765	-	0.794	0.672
Ecooper_2	0.928	-	0.900	0.533
Ecooper_3	0.928	-	0.923	0.719
Ecooper_4	0.907	-	0.867	0.983
Ecooper_5	0.815	-	0.702	0.940
Organizational performance				
Orgper_1	0.923	0.821	0.833	0.769
Orgper_2	0.832	0.852	0.812	0.692
Orgper_3	0.888	0.834	0.932	0.842
Orgper_4	0.974	0.809	0.907	0.901
Orgper_5	0.774	0.864	0.849	0.797

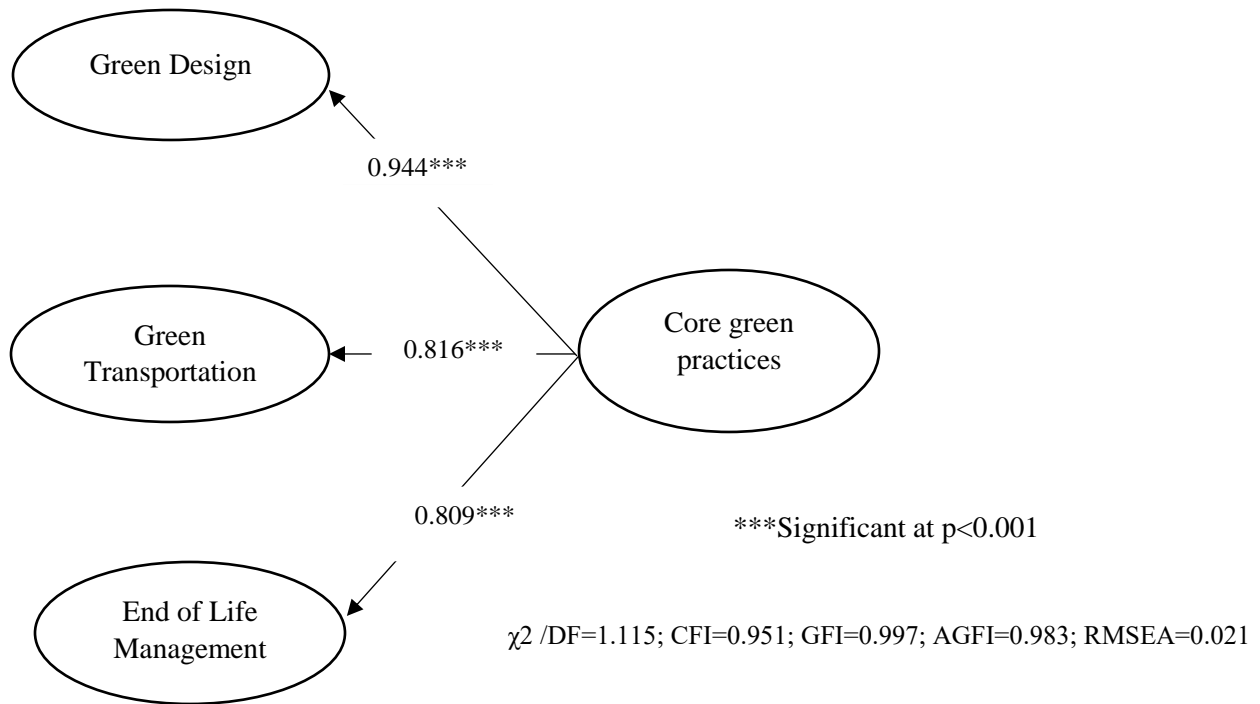
*shaded cells indicate factor loadings less than 0.5; ^aindicate the item only relevant to Developer; ^bindicate construct only relevant to Developer and Architect/Consultant; ^cindicate item not relevant for supplier; ^dindicate item not relevant for Developer and Architect/Consultant, ^eindicate green construction is relevant for contractor and corresponding practice for supplier is green manufacturing, ^findicate items only relevant to contractors

Appendix E – Second order confirmatory factor analysis of core green practices

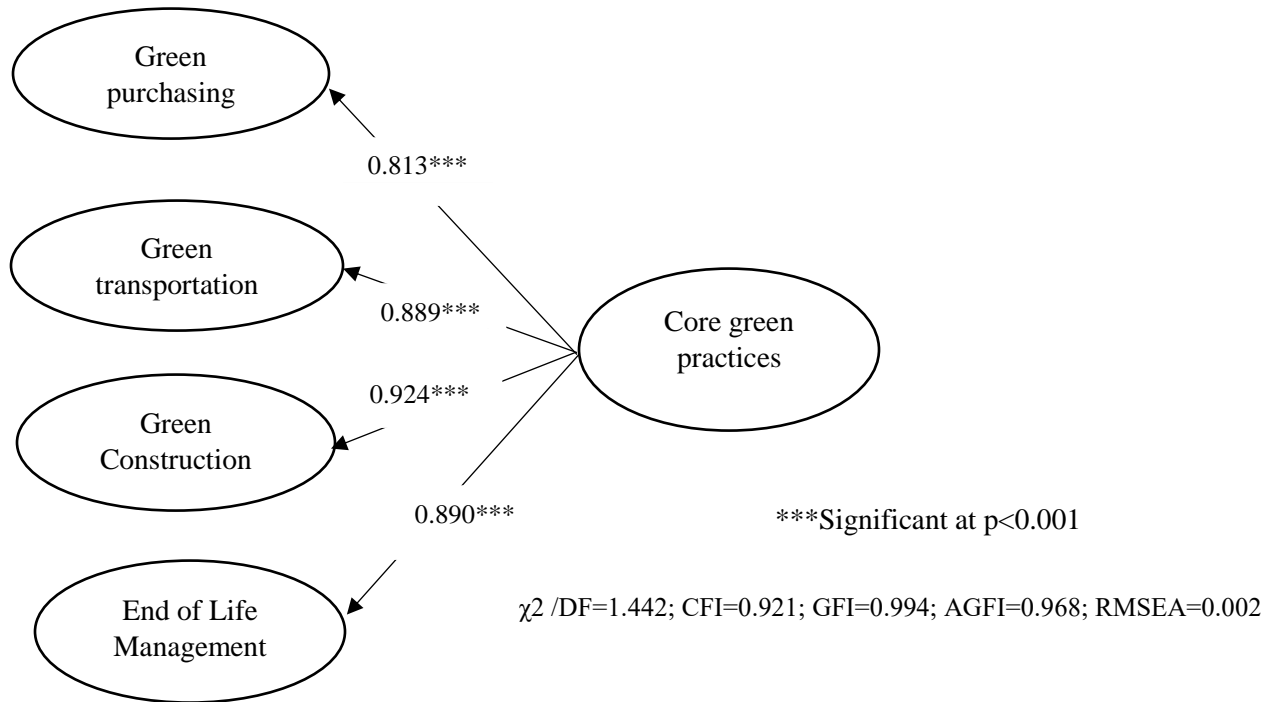
Developers



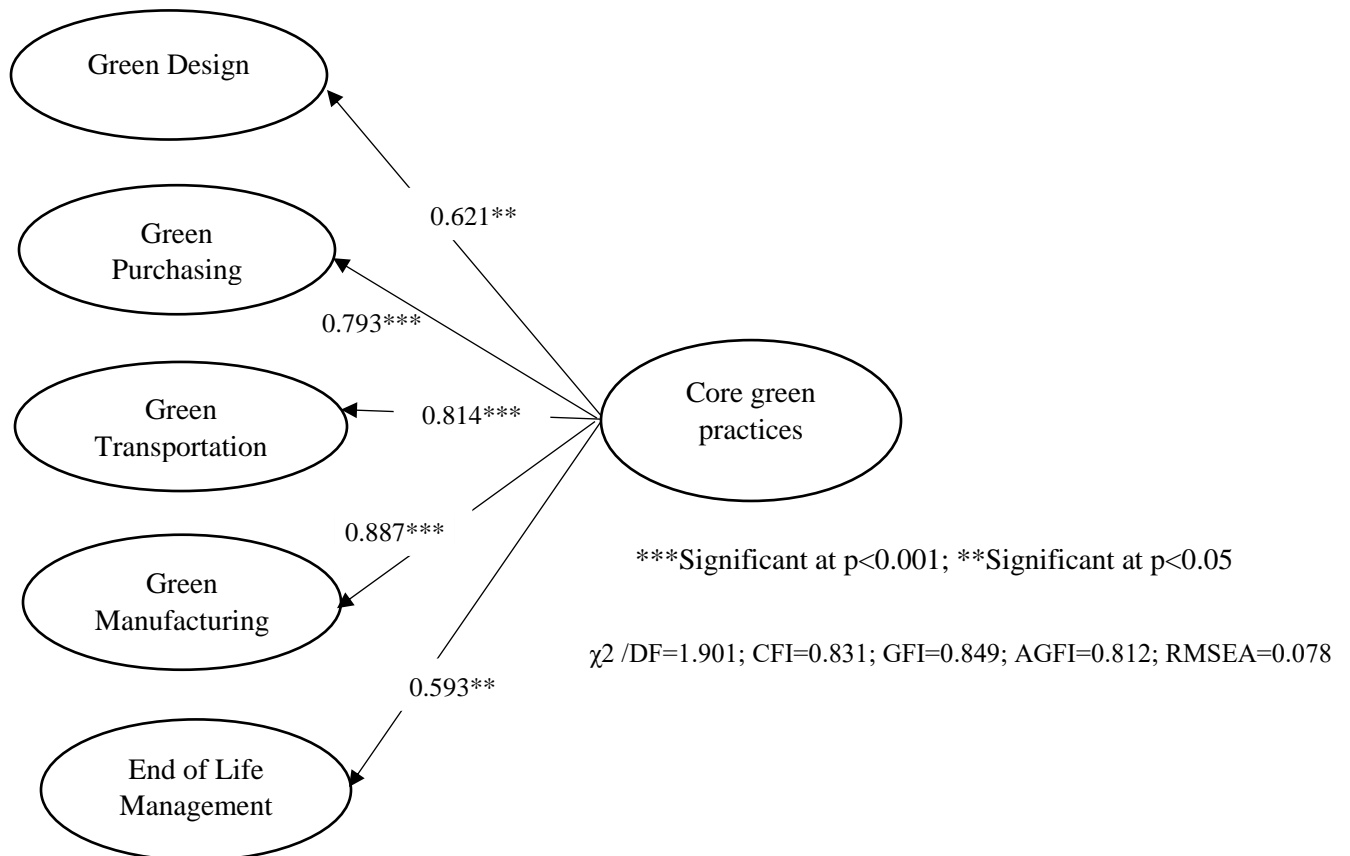
Architects/Consultants



Contractors



Suppliers



Appendix F – Summary of strategic level findings and hypotheses test results

