Contextual Factors of Sustainable Supply Chain Management Practices in the Oil and Gas Industry

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Wan Nurul Karimah Wan Ahmad

Delft University of Technology

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Cover photo: Sunset over Trinidad oilfield by Nathan Paculba

Contextual Factors of Sustainable Supply Chain Management Practices in the Oil and Gas Industry

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Preface

The relationship between sustainability and the oil and gas industry fascinates me because of their contradiction. How can oil and gas be sustainable because everything right from their exploration to their use could harm the environment. However, we rely heavily on these natural resources in economic activities and in our daily lives, and may still need to depend on them in the coming decades until commercially viable alternative energy sources become more accessible. We need to, therefore, improve our understanding of the challenges that confront the oil and gas industry in its efforts to minimize (or eliminate) the negative impacts, as well as enhance its compatibility with a sustainable future. In my PhD research, I tried to find some answers on how the industry can address these issues by focusing on its sustainable supply chain management practices. It took me nearly 6 years to find that potential answers, which is not possible without the help of so many people.

Without doubt, my promotor and supervisors have played a huge role in guiding me throughout this journey. Lori, I could never ask for a better promotor. The many discussions and talks we had have not only guided me in my research endeavor, but also helped me survive some major setbacks in my research and my life. Your enthusiasm and ability to visualize a problem clearly are the traits I hope to acquire myself. Jafar, I am so lucky to have you as my supervisor! I have said this to you before, I wish I could be a better student to you. I could never thank you enough for your support and patience during the last 4 years. Finally, Marisa, thank you so much for your guidance, support and patience, especially during the early years of my PhD journey. You were instrumental in shaping the focus of my research. Thank you very much for being involved in the research and always showing great interest in my progress even after you left TU Delft.

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I would also like to thank Prof. Hans Bakker for his help with my research. Thank you to the experts and companies who participated in my interviews and surveys. Many thanks are due to a master student, Saman Sadaghiani, for his great help with the study in Chapter 4. Thank you to Nathan Paculba for allowing me to use his beautiful picture on the cover of my thesis, and to Conchita for helping me with the thesis printing process.

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Finally, my family. To my sisters and brothers, thank you for your support and prayers throughout these years. To my parents, che and ayah, no words can express how lucky I am to be your daughter. Thank you for believing in me and giving me the freedom to shape my life. Thank you for always reminding me about the value of knowledge and the importance of sticking to what I set out to do. Ayah, this is almost two years too late… but, I know you are watching me and I hope I made you proud. This one is for you and che, I love you all very much.

Karimah
Delft, August 2016

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1. Introduction

1.1 Research background

Modern society is built upon the use of energy to satisfy our needs for transport, light, heat and power. Energy is so fundamental to our lives, without which disruptions in economic activities and reduction in quality of life could occur. Traditional sources of energy include, among others, human and animal labour, biomass from wood stocks, oil kerosene, windmill and watermill (Fouquet, 2010). The period of the nineteenth century saw the inventions of new energy technologies such as electric dynamo, steam engine and internal combustion engine that allow us to exploit energy sources more efficiently, especially from fossil fuels (Fouquet, 2010, Smil, 2005). Fossil fuels became the world's major source of energy approximately around the 1890s, mainly from coal, which was then gradually replaced by crude oil and natural gas as primary energy by the 1970s (Smil, 2005).

Advances in exploration, refining and transportation technologies of oil and gas (O&G) enabled rapid development of these sources to fulfill our growing demand for energy. BP projected that global consumption of energy will grow by 37% between 2013 and 2035. The O&G industry is estimated to account for approximately 55% of the total energy sources in that period (BP, 2015). Crude oil has high energy density and easy to be transported, while natural gas has low sulphur content compared to other fossil fuels (Smil, 2005). These advantages are among the factors that contribute towards the prevalence of O&G especially in transportation, heating and electricity generation. Concerns regarding future availability of conventional O&G and increased competition to access existing reserves have led to oil transition in the industry where greater focus is put on the development of unconventional O&G (Farrell and Brandt, 2006, Wolf, 2009). This has unlocked reserves located in unconventional locations such as deep water and the arctic, as well as from unconventional sources like shale and tar sands (Farrell and Brandt, 2006, Ziegler et al., 2009). However, O&G exploitation comes at great expense to the environment as well as public health and safety.

Exploration, production, transportation and conversion of O&G can cause negative impacts to the environment such as water pollution, biodiversity degradation, and emissions of

greenhouse gases (GHG). This can affect societal wellbeing, especially to host communities due to, for example, exposure to the release of toxic substance and gases, displacement of traditional community structure and loss of provisions for local communities that depend on nature for their livelihood.

Therefore, there are growing concerns regarding the compatibility of the O&G industry in sustainable future. This has led to the call for O&G to be replaced with low carbon and renewable alternative energy. The current development of alternative energy is slow and cost-intensive; it would take years for the energy to be developed economically and to achieve energy efficiency levels that would allow it to replace O&G. Even though the alternatives will gain increasing share in the future energy mix, O&G however, are projected to remain as the most important sources of energy for decades to come (BP, 2015, Fouquet, 2010). This implies that the sustainability of the O&G industry's operations and products are pressing issues that must be addressed promptly to minimize or eliminate the risks involved.

One way that this can be done is through the integration of sustainability dimensions in supply chain management (SCM) practices in the O&G industry. SCM is defined as the systemic and strategic coordination of traditional business functions and the tactics across these functions to improve the long-term performance of a supply chain and its members (Mentzer et al., 2001). It is a bi-directional integrative function of material, information and service processing links of not only the internal supply chain of a business, but also all of the upstream and downstream members of the supply chain (Chen and Paulraj, 2004).

SCM plays a substantial role in facilitating the globalization of the world economy (Halldórsson et al., 2009), since production processes are often dispersed around the globe (Mentzer et al., 2001, Seuring and Müller, 2008). However, society is paying a high price in terms of environmental shortcomings for the economic advantages gained from this phenomenon. Consequently, the issues occurring outside organizational boundaries with regard to SCM have attracted growing academic and corporate interest, which has resulted in increasing efforts to integrate sustainability principles into SCM practices (Dakov and Novkov, 2008). This extension to SCM, generally known as sustainable supply chain management (SSCM), concerns supply chain design and operations that emphasize environmental and social responsibility beyond the ownership and uses of a particular product or services throughout the supply chain, to also include its end-of-life considerations.

SSCM can be defined as strategic and transparent integration and achievement of economic, environmental and social goals of an organization through systemic integration of key business functions and processes, and cooperation among supply chain members (Carter and Rogers, 2008). The adoption of SSCM strategy is facilitated by managerial actions and decisions that are taken to manage material, information and capital flows, as well as cooperation with supply chain partners to create a sustainable supply chain and achieve sustainability goals based on customer and stakeholder requirements (Seuring and Müller, 2008, Pagell and Wu, 2009).

Sustainability is becoming a key survival issue for companies amid the mounting pressure by the public for more responsible practices (Dhiman, 2008), and from increasing awareness of environmental and social burden associated with their activities (Seuring and Müller, 2008). Perhaps more than any other industries, the sustainability of the O&G supply chain should be a major concern since it has become a deeply entrenched foundation from which many industries and lives are built. The challenges in the implementation of sustainable practices in the O&G industry is not just to arrive at environmentally and socially responsible operations throughout its supply chain, but also to enable the industry to adapt to the changes in its business environment in timely manner. This is to ensure that it could evolve and remain relevant in sustainable future alongside cleaner energy options to deliver sustainable energy supply.

Despite its importance, little attention is given to the O&G industry in the sustainable operations and SCM literature (Hussain et al., 2006). Therefore, there is a lack of understanding of the sustainability issues and challenges confronting the industry in its supply chain activities, as well as the SSCM strategy that can be adopted according to its operating context.

1.2 Problem statement

The O&G supply chain is characterized by complex networks of companies, involved in highly specialized activities at every stage of the chain, from upstream exploration and production activities to downstream refining and distribution practices. This complexity has necessitated research into supply chain modelling aimed at, among others, improving its logistics systems, production and operation planning, inventory management and minimizing disruptions in supply networks. The first study on supply chain management within the O&G industry context was conducted by Sears in 1993, which focused on the downstream logistics planning of oil companies (Neiro and Pinto, 2004). Generally, the goal of this and many latter studies were to achieve efficiency improvements through lead time and cost reductions, involving optimization modelling or simulation approaches. As yet, little attention has been devoted to the sustainability aspects of the supply chain.

Lakhal et al. (2007) note the lack of research in the area of sustainable supply chain of O&G. They conducted the first study on green supply chain management (GSCM) in the industry, specifically for oil refineries application. However, GSCM studies do not consider the social aspect of supply chain sustainability, and largely focused on the environmental aspect. Other sustainability-related studies include integration of corporate social responsibility in supply chain practices (Midttun et al., 2007), life cycle analysis (Vlasopoulos et al., 2006, Lakhal et al., 2009), closed-loop GSCM (Li and Jianming, 2009), GHG emissions (Brandt et al., 2010, Sealy and Dunlop, 2010), laws and regulations (Wagner and Armstrong, 2010), and risk management (Cigolini and Rossi, 2010). Recent studies are about the adoption of sustainable measures and performance outcomes (Yusuf et al., 2013), sustainable sea transport outsourcing strategy (Tesfay, 2014), and local content practices (Ngoasong, 2014, Ablo, 2015). Overall, sustainable supply chain studies in the O&G industry context is still fragmented where there is a lack of systemic or multidimensional research that focus on:

1. Triple bottom line of sustainable practices, i.e. economic, environmental and social dimensions;
2. Internal and external factors that can affect the implementation of sustainable supply chain strategy in the O&G industry;
3. Sustainability strategy of different functional areas in O&G supply chain; and
4. Development of SSCM strategies that facilitate the alignment of companies' internal organizational environment with their external business environment to achieve supply chain sustainability goals.

Halldórsson et al. (2009) propose that further studies should be conducted to identify the contextual factors of a sustainable supply chain strategy. They note that most SSCM studies concentrate on micro perspective; i.e. stakeholder concern regarding the impact of companies' activities on the environment and society, and the approach to achieving SSCM, such as reverse logistics, carbon footprint reduction and green supply chain. Research from macro perspective is needed since sustainability may be an external factors that could affect supply chain design and operation (Halldórsson et al., 2009). For example, researchers could

examine how the interplay between factors within business environments creates sustainability pressure on supply chain management practices.

Surana et al. (2005) suggest that every company can affect the overall performance of its supply chain by engaging in the chain activities through localized decision-making practices. It is therefore important to identify the contextual factors within the external business environment and internal organizational environment that could affect SSCM practices. This will allow us to understand the relationship between the contextual factors and sustainable supply chain strategies adopted by the company. Consequently, we will be able to understand a supply chain's collective behaviour towards SSCM practices.

SSCM studies specific to the O&G supply chain context are needed because the industry may be facing sustainability pressures that are different than other industries. The O&G industry operates in diverse environmental, socio-economic, political and regulatory settings (Wagner and Armstrong, 2010). These external forces, including technology progress, emergence of alternative energy, social and environmental concerns (Edwards et al., 2010), may determine companies' responses to the pressure to operate sustainably in their supply chains.

For example, the O&G industry is highly regulated compared to automobiles industry (Zhu et al., 2007). It is also a truly international industry, e.g. a Dutch company may be developing O&G reserves in the Middle East that will be transported to Asia to be further refined into products to satisfy demands in Europe. Companies in the industry, therefore, can be subjected to different regulatory requirements that can cause uncertainties to the sustainability of their supply chain operations. Increased competition from cleaner alternative energy may force companies to improve their environmental sustainability. However, O&G are carbon-intensive sources that can never compete with the alternatives in environmental areas. Therefore, they might respond to the pressure through strategies that can help secure their competitive position, which might cause trade-off between economic, environmental and social sustainability.

The inherent carbon-intensive nature of O&G is an inescapable stumbling block to the O&G industry's sustainability efforts. The question therefore becomes, can the industry ever be sustainable? The immediate answer that comes to everyone's mind is probably in the negative. Or, some might think that the industry can achieve an acceptable level of sustainability if conducted on a smaller scale, complemented by a transition to low carbon energy systems that include more prominent role of alternative energy. That is in essence, one of the resolutions achieved by the recently concluded 2015 United Nation Climate Change Conference (COP21) in Paris. Although energy transition can affect all industries, the O&G industry is essentially at the core of the transition. Any regulatory or fiscal policies introduced to spur the speed of the transition and promote the development of alternative energy will affect the industry and its future survival. The industry is estimated to lose approximately $33 trillion of revenue within the next 20 years as a result of the climate and carbon emissions deals reached at COP21 (CA, 2015).

It can be argued that companies that are equipped with appropriate internal resources and competences will be able to manage the sustainability pressure resulted from their external environment complexities. As of yet, little is known about the interplay between these internal and external contextual factors in influencing companies' sustainable supply chain strategies. Thus, a study is needed to operationalize these factors. Understanding the relationships between the factors is one of the first steps towards identifying the O&G industry's responses to the pressure to operate sustainably. In addition, it will help us identify how SSCM strategies can be integrated and implemented more effectively in the management of its supply chains.

1.3 Research objectives and questions

The lack of understanding on the contextual factors that could affect the adoption of SSCM practices in the O&G industry must be addressed. Therefore, the main aim of this thesis is:

> *To explore the influence of the contextual factors within the O&G industry's external business environment and internal organizational environment on its implementation of SSCM practices.*

Based on the main research objective, several research questions are formulated in order to achieve it. The questions, which mirror the more specific objectives of this thesis, are as follows.

RQ1: What are the factors within the O&G industry's external business environment and internal organizational environment that can influence its implementation of SSCM practices?

RQ2: What are the sustainable supply chain strategies adopted by companies in the O&G industry?

Galbraith (1973) argues that the best way for an organization to organize itself is contingent upon the environment in which it operates. A strategy that works for a product, a company or an industry, for example, may not be equally effective for others (Galbraith, 1973). With these questions, we are therefore interested in exploring and identifying the internal and external contextual factors that could drive (or hinder) the implementation of SSCM practices in the O&G industry. In addition, we aim to identify the sustainable supply chain strategies that are being applied in the O&G industry context.

RQ3: To what extent do companies in the O&G industry communicate their commitment and performance related to sustainable practices?

Through the third research question, we aim to obtain an overview of sustainable practices in the O&G industry, by examining the disclosure of its commitment and performance related to the practices. By answering this question, we will be able to determine whether the commitments expressed are consistent with the disclosure of their actual performance. In addition, it will allow us to understand how the pressures for sustainable practices are addressed through public disclosure of sustainability initiatives and performance.

RQ4: What are the most important external factors that can influence the O&G industry's adoption of SSCM practices?

As every company or industry operates within an environment that is unique to its characteristics, the challenges involved in achieving sustainable supply chain may be different for each. This is especially true when we consider the various factors that companies have to deal with from their external environment, which are often beyond their control. Therefore, through the fourth research question, we are interested in identifying the most important external factors that can influence SSCM practices in the O&G industry. This will help us identify the factors that companies should pay more attention to or should be prioritized in decision making processes related to SSCM implementation.

RQ5: What are the relationships between the external and internal factors with sustainable supply chain strategies?

The fifth and final research question concerns the relationship between the three central elements of this thesis: external factors, internal factors and sustainable supply chain strategies. We argue that SSCM strategies result from the interplay of factors within the external and internal contextual environments, as well as companies' interaction with the environments. Through this research question, we aim to identify the relationships between the contextual factors and sustainable supply chain strategies. This allows us to understand how the factors can drive or hinder the adoption of SSCM practices among companies that operate in the O&G industry.

1.4 Research methodology

This research is a cross-sectional study that uses a mixed methods approach to answer the research questions and to achieve its objectives. In order to clearly understand research problems, this approach uses inquiry strategies that involve simultaneous or sequential data collection of both quantitative and qualitative information (Creswell, 2009). The use of a mixed methods approach enables a researcher to test consistency of findings obtained through different instruments as well as provides detailed explanation of a scenario being studied.

Generally, this thesis begins with the formulation of research objectives and research questions, followed by a more thorough review of literature related to SSCM and sustainable practices in the O&G industry. The literature review allows us to identify the state-of-the-art of research in these areas, and identify the internal organizational factors, external business environment factors, and SSCM strategies that are relevant to this research. In addition to literature review, a content analysis of sustainability reports of O&G companies is conducted to obtain an overview of sustainable practices in the industry. This is accomplished by analysing companies' disclosure of their commitment and performance related to the practices.

The factors found through the review form the basis of the conceptual framework of this thesis. The framework illustrates the relationship between contextual factors within O&G industry's environments and SSCM strategies. We discuss the framework from organizational perspectives, specifically its linkages to three complementary organizational theories: institutional theory, stakeholder theory and dynamic capabilities theory.

Institutional theory and stakeholder theory help us describe how external business environment factors can influence companies' strategies related to SSCM practices. According to institutional theory, business strategy can be affected by external forces such as political, economic, regulatory agencies, competitors, and industry norms that create isomorphic response to coercive, mimetic and normative pressure (DiMaggio and Powell, 1983, Scott, 2005). Oliver (1991) argue that firm's response to the pressure varies and may be driven by active organizational behaviour and interest-seeking nature of the firm in order to obtain stability and legitimacy. Stakeholder theory is about groups that can affect or be affected by organization actions, and about managerial behaviour as they respond to those groups to create value (Freeman et al., 2004, Donaldson and Preston, 1995). Institutions and stakeholders are interdependent and together they could determine how organizations develop their strategy to respond to external influence and sustainable development pressure (Lee, 2011, Wu et al., 2012).

Dynamic capabilities theory, on the other hand, helps us explain how internal organizational factors (i.e. resources and capabilities) can facilitate the implementation of

SSCM practices in the companies. Dynamic capabilities include firm's ability to sense, seize and reconfigure itself in order to develop and exploit internal and external competences, as well as adapt to and shape its environment (Teece et al., 1997). The application of dynamic capabilities theory is relevant to SSCM field since both share similar environmental and organizational conditions that allows companies to adapt to changing environment and pressures (Beske, 2012).

In order to test the influence of the external factors and internal factors on sustainable supply chain strategies proposed in the conceptual framework, we develop a questionnaire that contains their measurement items based on the literature and feedback from industry experts. A survey among companies that operate along the upstream and downstream O&G supply chain is conducted to collect the necessary data using the questionnaire. Data gathered are analysed using descriptive and inferential statistical analysis.

In the broader SSCM field, there is a growing literature that explores the internal and external factors that could affect SSCM practices. However, studies with regard to the importance of the external factors in influencing SSCM practices in the O&G industry context are limited. Therefore, we conduct a survey to assess the importance of the factors. The survey is conducted among academic experts in the supply chain and O&G field due to their accessibility and familiarity with the issues being studied. Data gathered from academic perspectives can provide valuable insights that can be compared with data from industry perspectives. We analyze the data using a new multi-criteria decision-making (MCDM) method called Best Worst Method (BWM).

Overall, this thesis develops a conceptual framework of the contextual factors of SSCM practices in the O&G industry based on a review of literature and industry reports. It then explores the relationships proposed in the framework by testing the relationships through empirical analysis and examining its linkages with three organizational theories. Based on the results of our analysis, we identify several implications for SSCM practices in the O&G industry and for further investigations of this research area.

1.5 Research significance

This thesis contributes towards furthering our understanding of the contextual factors that could drive or hinder SSCM practices in the O&G industry. There are three aspects in which it helps in achieving such understanding.

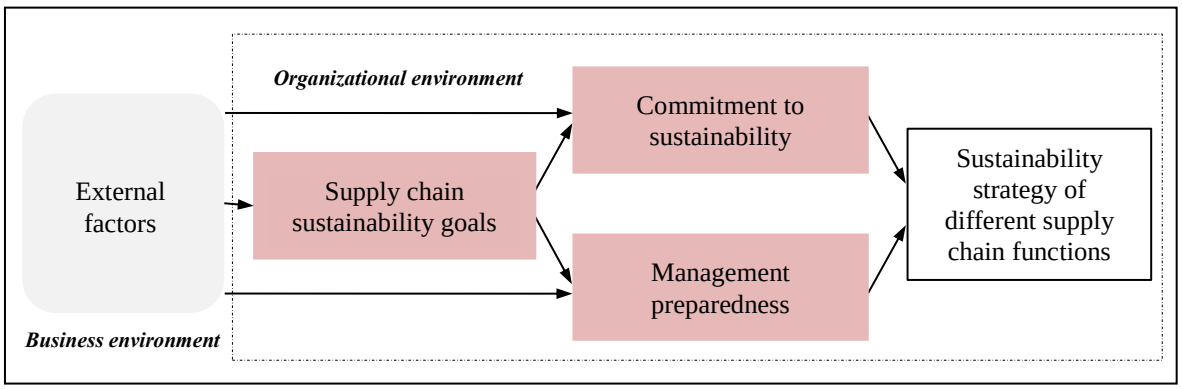

Figure 1.1 – Conceptual framework of SSCM in the O&G industry

First, we develop a multidimensional conceptual framework of SSCM in the O&G industry operationalizing the contextual factors that can influence its adoption of sustainable supply

chain strategy, as shown in Figure 1.1. While various studies have been conducted to examine the internal and external drivers of SSCM, studies in the O&G supply chain context are scarce. Furthermore, the framework incorporates different supply chain functional areas that are involved in acquisition of materials/resources, their conversion and distribution into products or services to satisfy customer requirements. Currently, there is no study that examines SSCM practices in the O&G industry context from this multidimensional perspective.

The second aspect that differentiates this research from the existing SSCM studies is the inclusion of supply chain sustainability goals as a distinct internal factor that can affect supply chain strategies. Sustainability goals are often discussed in SSCM literature with regard to its integration in corporate and functional strategies (Wolf, 2011, Harms et al., 2013), supply chain performance measurement (Wittstruck and Teuteberg, 2012, Darnall et al., 2008) and in resources and capabilities development (Paulraj, 2011). Very few studies incorporate sustainability goals as an explicit factor in SSCM framework, notably Hervani et al. (2005) and Pagell and Wu (2009) studies. We extend these studies by examining the role that sustainability goals can play in aligning companies' internal and external environment. We argue that understanding this role can facilitate the formulation of more effective sustainable supply chain strategies.

Third, the O&G industry occupies a unique position in sustaining the world's economy and our lives, but it is also the cause of sustainability problems we face today. Through this research, we want to understand how companies in the industry respond to the sustainability pressure exerted by the factors within their external environment using internal resources and capabilities to implement sustainable supply chain practices. While all industries might seem to operate within similar external environment, we think that the O&G industry experiences greater external pressure for sustainable practices compared to other industries due to its strategic importance and prevalence in social as well as economic activities. The interactions among factors within the external environment create contextual uncertainties that can increase sustainability pressure on the O&G industry. We operationalize the factors to gain some insights on how it can influence the industry's adoption of SSCM practices.

Overall, this thesis can contribute towards furthering our understanding of SSCM practices in the O&G industry context. The conceptual framework proposed aims to explore the O&G industry's external and internal environments that can affect its SSCM practices from multidimensional perspective. Specifically, this thesis adds to the discussions that SSCM strategies result from the interplay between the internal and external factors within companies business and organizational environments, and their interaction with the environments.

1.6 Outline of thesis

Figure 1.2 shows the outline of this thesis, which is based on the work conducted to understand the internal and external contextual factors of SSCM practices in the O&G industry.

In Chapter 2 this thesis discusses the conceptual framework proposed to study the contextual factors of SSCM practices in the O&G industry. The framework operationalizes the internal and external factors in the industry's business and organizational environment that can influence its adoption of sustainable supply chain strategies.

Next, Chapter 3 presents the results of a content analysis of sustainability reports of O&G companies. It is an exploratory study that aims to gain an overview of the sustainability reporting practices of companies in the industry, and the integration of sustainable practices in their supply chain management.

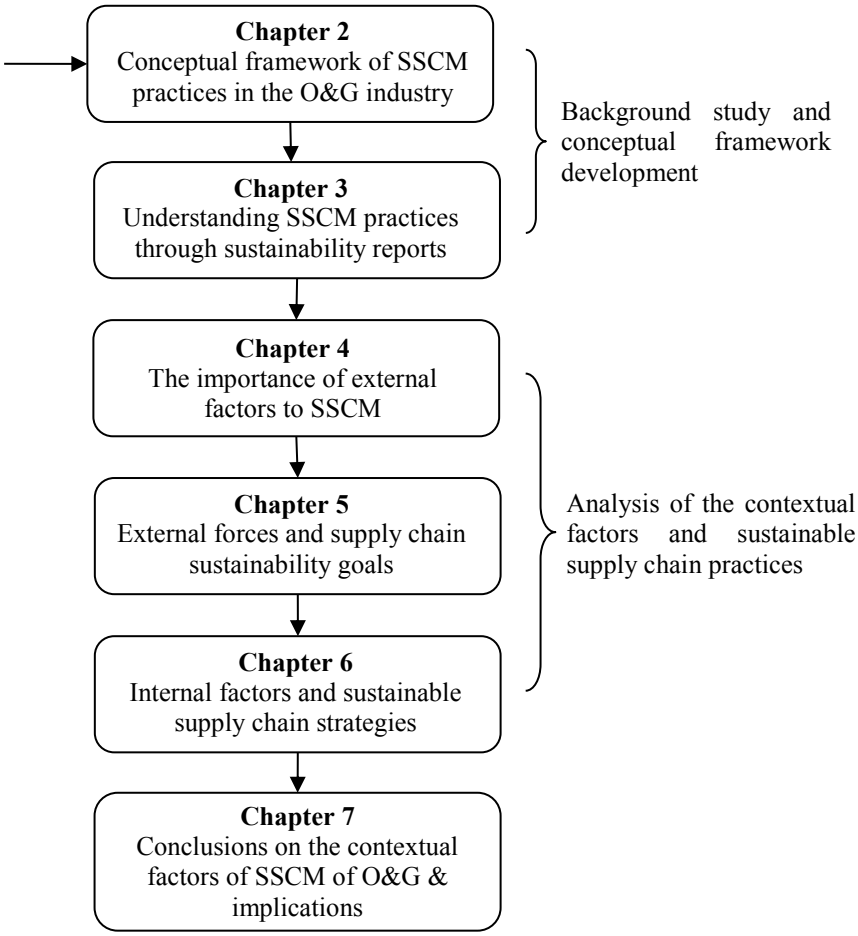

Figure 1.2 – Thesis outline

Chapter 4 focuses on the importance of external factors in influencing SSCM practices in the O&G industry. This chapter sheds some light on this issue based on a study among academic experts in the field of O&G and SSCM.

In Chapter 5 and Chapter 6, this thesis discusses the results of an industry survey conducted to understand the relationships between contextual factors and supply chain sustainability strategies. Specifically, Chapter 5 focuses on the relationships between external business environment factors and supply chain sustainability goals. Chapter 6, on the other hand, discusses the relationships between internal organizational factors (commitment to sustainability and management preparedness) and sustainable supply chain strategies adopted by companies. The results of the survey are presented in two separate chapters to allow for more detailed discussions of the relationships between the factors examined in this thesis.

Finally, Chapter 7 discusses the substantive findings regarding the contextual factors of SSCM practices in the O&G industry as well as the drivers and barriers to the practices. This is based on the studies discussed in the previous chapters. It also presents the scientific and managerial implications of the studies, as well as opportunities for further research.

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2. Conceptual Framework for Sustainable Supply Chain Management Practices in the Oil and Gas Industry

This chapter is based on: Wan Ahmad, W.N.K., de Brito, M., Rezaei, J. and Tavasszy, L.A. (2016) "An integrative framework for sustainable supply chain management practices in the oil and gas industry". Journal of Environmental Planning and Management. doi: 10.1080/09640568.2016.1178105

2.1 Introduction

This chapter presents the conceptual framework of this thesis. It discusses the internal and external contextual factors that can influence the implementation of sustainable supply chain management (SSCM) practices in the oil and gas (O&G) industry. The framework is developed based on a literature review around the key topic areas of SSCM and sustainability practices within the industry. We identify the relevant factors through the literature, classify them, describe their interactions, and map the factors in a framework. This chapter will also discuss the framework from organizational theory perspectives. Specifically, it linkages to three theories namely institutional theory, stakeholder theory and dynamic capabilities theory. The following research questions guide our literature search and conceptual framework development:

1. *What are the factors within the O&G industry's external business environment and internal organizational environment that can influence its implementation of SSCM practices?*
2. *What are the sustainable supply chain strategies adopted by companies in the O&G industry?*

The structure of this chapter is as follows. Section 2.2 defines SSCM, followed by Section 2.3 that describes the methodology used to develop the conceptual framework. Section 2.4 discusses current SSCM studies related to the O&G industry. In Section 2.5 we discuss the conceptual framework, and in Section 2.6 discuss the framework from organizational theory perspectives. The final Section 2.7 concludes this chapter with a summary of its main highlights.

2.2 Sustainable supply chain management defined

Global concerns regarding climate change, unsustainable use of natural resources and economic slowdown are forcing businesses to reconsider the way they operate. Many of them are incorporating the sustainability agenda, involving control of the triple-bottom-line (TBL), i.e. economic, environmental and social performance, in their operations (Dhiman, 2008). TBL was introduced by Elkington who stresses that social and economic dimensions of sustainability must be addressed in a more integrated way to enable real environmental progress (Elkington, 2004). According to Carter and Rogers (2008), the micro-economic perspectives of sustainability have been applied more often in research than the macro-economic perspectives. This could be due to the difficulty in identifying the effective way of addressing sustainability in a broader context when various, often conflicting, issues need to be considered simultaneously.

Carter and Rogers (2008, p. 368) define SSCM as “the strategic, transparent integration and achievement of an organization’s social, environmental, and economic goals in the systemic coordination of key organizational business processes for improving the long-term economic performance of the individual company and its supply chains”. According to Seuring & Muller (2008b, p. 1700), SSCM is “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”. Pagell and Wu (2009), meanwhile, simply define it as the managerial decisions and behaviours designed to ensure that a supply chain performs well in the TBL dimensions to create a truly sustainable supply chain.

These definitions imply that managerial decisions and behaviours should be aimed at ensuring that both individual companies and their supply chain as a whole perform well economically, environmentally and socially, through a strategic integration of key business processes in the management of resources and the delivery of products and services. To achieve sustainable practices, companies should move beyond their immediate concern, which is to gain profit, and take appropriate steps to protect the environment and society wellbeing. The companies must employ new strategies to achieve joint optimization of these sustainability aspects, including through waste optimization, carbon footprint reduction, green purchasing and green product design (Srivastava, 2007), which in essence are part of supply chain management (SCM) (Markley and Davis, 2007).

A sustainable O&G supply chain practices is crucial because the demand for energy will continue to increase in the future. By 2035, approximately 81% of the energy supply will be from fossil fuel sources (i.e. including coal) (BP, 2015). The environmental and social implications of unsustainable exploitation of these resources can be devastating. The implementation of SSCM practices should help to minimize, if not eliminate, the negative impacts, while allowing the industry to sustain itself economically and ensure energy security. This requires close cooperation between all supply chain members and the integration of key activities throughout the industry’s supply chain. The industry must work together with its

stakeholders, such as governments, local communities, suppliers, customers and employees to solve its sustainability issues to deliver a more sustainable O&G supply.

2.3 Conceptual framework development

According to Meredith (1993, p. 8), a framework "may identify relevant variables, classify them, describe their interactions, and allow a mapping of items (such as the existing literature or research studies) on to the framework". This thesis proposes a framework that can be used to describe the key contextual factors of SSCM and explain their relationships in the context of the O&G supply chain. We adapted the methodology used by Seuring and Muller (2008b) in our literature search to develop the framework.

Literature review on studies related to SSCM of O&G was conducted to identify the state of current research in the area. The studies were identified through structured keyword search (i.e. "supply chain", "sustainable", "green", "oil and gas", and "petroleum") in four electronic databases, namely: Emerald, Elsevier, Springer and Wiley. Additionally, Google Scholar was also used. The four major academic databases and Google Scholar were chosen because of the extensiveness of their coverage of academic literature related supply chain management, O&G industry and sustainable development. The journal articles found through the databases were examined for their relevance to this research: (1) all studies where O&G industry is the main focus, or is part of the researched area, were selected; and (2) studies on sustainable development of O&G where their relationship to SCM was not clear were excluded, e.g. studies on corporate governance practices among O&G companies.

The literature search was conducted for papers which were published until 2012. Studies on SCM within the O&G context began around the early 1990s (Neiro and Pinto, 2004), and the integration of sustainability within the SCM field has only gained prominence during recent years. This is confirmed by the results of the literature search, where the earliest study found was conducted by Min and Galle (2001). However, the study includes other manufacturing industries besides the oil/gas extraction and petroleum refining industry. The earliest studies specific to the O&G industry were published in 2007. Overall, we found ten papers related to sustainable or green SCM of O&G, as summarized in Table 2.1.

Table 2.1 – List of literature related to SSCM of O&G

Focus area	Author	Total
Sustainable/green SCM of O&G	Lakhal et al. (2007); Midttun et al. (2007); Lakhal et al. (2009); Deng and Liu (2011)	4
O&G is part of researched area	Min and Galle (2001); Zhu et al. (2007b); Matos and Hall (2007); Hartman et al. (2007); Zhu et al. (2008b); Zutshi et al. (2009)	6

Due to the lack of literature, we included all of the papers found. For that same reason, we also referred to the broader O&G studies, industry reports, such as the sustainability reports and industry guidelines related to O&G development. This is to increase our understanding of its supply chains and the sustainability issues involved. Additionally, we referred to the SSCM literature from other industrial areas (the search used the same databases mentioned earlier). This is to identify the factors that could be used to describe the context or the environment in which the O&G industry operates and the management of its supply chain. Based on the findings, we developed the first version of a conceptual framework that proposes the relationship between the contextual factors and SSCM practices in the O&G industry.

The framework was refined through discussions with colleagues and academic experts in areas ranging from SCM, transport and logistics to energy systems. Discussions were also conducted with operations, supply chain or sustainable development managers and practitioners who work in the O&G industry. These discussions helped us to ensure that relevant factors are included in the framework and the relationships between those factors are mapped correctly. This resulted in the final version of the conceptual framework. Throughout this process, we sought to ensure that the framework maintained its integrity with reference to the literature and industry reports consulted earlier.

2.4 Synthesis of literature on sustainable supply chain management in the oil and gas industry

The O&G industry consists of various players with different positions in terms of access to resources, technology, consumer markets, capital availability and expertise (Edwards et al., 2010). They can be categorized into operators (oil companies), main contractors, sub-contractors and suppliers (Anderson, 2003). Although the industry is often perceived as a single industry, it actually comprises companies from diverse backgrounds that represent various industrial cultures and areas of expertise (Dauda and Yusuf, 2009). Its supply chain can also be influenced by many internal (business-related) and external (political/ economic) forces (Anderson, 2003).

Generally, the supply chain of O&G is as illustrated in Figure 2.2 (Kilponen, 2010). In functional terms, the supply chain includes three different sections. The upstream section, widely known as exploration and production (E&P), is involved in finding and producing crude oil and natural gas. The downstream section produces and markets various refined petroleum and petrochemical products for public and corporate consumers. Occasionally, a midstream section is distinguished, involving storage and distribution of hydrocarbon products. We consider the midstream and downstream sections together in this thesis.

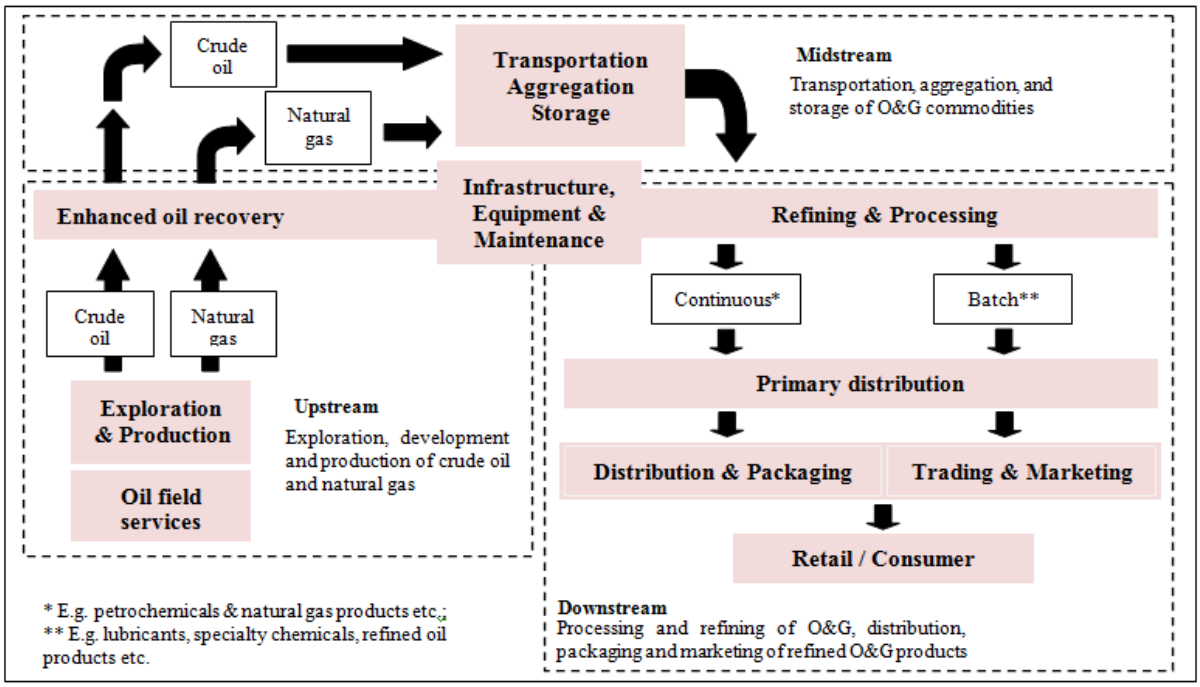

Figure 2.2 – Oil and gas supply chain and its industry segments (Kilponen, 2010)

In the upstream section, the decisions made during the E&P stage may include design and planning of oil field infrastructure (Neiro and Pinto, 2004). Many factors must be taken into consideration in this stage, such as the deployment of new or newly adapted E&P technologies, environmental laws and regulations which often vary between countries, and local socioeconomic issues (Elcock, 2007). The E&P facilities are decommissioned at the end of their commercial life, which can be about 20 to 40 years. The decommissioning process involves building and equipment removal, site restoration, implementation of site re-vegetation measures and continuous monitoring after closure (UNEP, 1997).

The downstream business of O&G involves decisions such as crude procurement, supply planning, logistics scheduling, storage scheduling and crude scheduling (Julka et al., 2002, Neiro and Pinto, 2004). Production planning generally focuses on the individual product's production level and refinery operating condition, while transportation focuses on scheduling and inventory management (Neiro and Pinto, 2004). In refinery operations, the decision-making process may be divided among various departments with conflicting objectives, which may negatively affect performance (Julka et al., 2002). In these cases there is a need for inter-departmental integration, since local improvements would not necessarily help in improving supply chain overall performance. Table 2.2 summarizes the characteristics of downstream O&G supply chain.

Table 2.2 – Distinguishing characteristics of O&G supply chain (adapted from: IBM, 2005)

Characteristic	Description
Long product life cycles	Stable and static product mix
Non-perishable products	Costly inventory holding, but costs are recoverable; downstream companies are not affected by aging and stock rotation issues
Less volatile demand	Demand may vary among petroleum companies, but market demand is more stable; demand does not change based on product innovation and consumer tastes
Less product to track	Stable and static product mix
Few methods of viable transport	Products are flammable, with a large distance between supply sources and consumer markets
Commodity-based and fungible inventory	Competitors can trade with each other; associated financial markets for both crude and refined products play a large part in how supply chains are managed, and these markets can be exceptionally volatile
Discontinuous supply chains	Inventory is often traded or resold several times before it is consumed (it can move in and out of companies' systems several times, which can increase transaction volume but not necessarily increase or reduce actual inventory)
Process-based and non-discrete inventory	Inventory is not packaged and can't be separately identified
Reversed production flow	Inventory starts as few products (crudes) and creates many products that can be combined – an end product can be created in many different ways
Legal and environmental regulations	Mandate minimum inventories, raise antitrust concerns, require unique reporting, and emphasize safety and quality of the end product
Inflexible assets	Inherent processing complexities of a refinery only permits narrow ranges of capacity changes; difficult and risky production stopping and restarting
Transportation costs and low relative value	By limiting the number of locations, products can be shipped cost-effectively

Currently, very few research on the sustainability of the O&G supply chain is reported in the scientific literature. Table 2.3 summarizes the studies related to sustainable or green SCM in the O&G industry found through literature search. We find that none of the existing studies particularly examines different stages of the O&G supply chain and incorporates all the TBL dimensions of sustainable development. Most studies focus on economic and/or environmental issues that are specific to a certain stage of the supply chain. Only one study incorporates the three dimensions of sustainability. In terms of the supply chain stages, the

sustainability of E&P has been studied most. Studies that include O&G as one of the researched areas generally focus on no particular stage, which can be attributed to the broad nature of the industries involved.

Table 2.3 – Summary of SSCM of O&G papers found through literature search

Author	Year	TBL dimension			Supply chain stage (SCS)				No focus
		*ECO	ENV	SOC	E&P	R&P	LOG	T&R	on any SCS
Min & Galle	2001	•	•		x	x			
Zhu et al.	2007b	•	•						x
Hartman et al.	2007			•					x
Lakhal et al.+	2007		•			x	x		
Midttun et al.+	2007		•	•	x				
Matos & Hall	2007	•	•	•	x				
Zhu et al.	2008b	•	•						x
Zutshi et al.	2009	•		•					x
Lakhal et al.+	2009	•	•		x				
Deng & Liu+	2011		•						x

*ECO: Economic, ENV: Environment; SOC: Social, E&P: Exploration & Production, R&P: Refining & Processing, LOG: Logistics, T&R: Trading & Retail
+ Papers specific to O&G supply chain

Lakhal et al. (2007) conducted one of the first studies specific to the O&G supply chain. They note that there were no green supply chain management (GSCM) studies in the petroleum industry prior to their research. Their study introduced the "olympic" green supply chain (OGSC) concept that aims to ensure that all resources used during refining operations result in five zeros of waste or emissions. This includes zero: (1) emissions, e.g. air, soil, and water, (2) waste of resources, (3) waste in administration activities, (4) use of toxics, and (5) waste in product life cycle (Lakhal et al., 2007). Their later study demonstrated the applicability of the concept in identifying the economic, environmental and social imbalances in the decommissioning process and inefficient resource utilization in the O&G production life cycle (Lakhal et al., 2009).

A study on the offshore petroleum industry was conducted by Midttun et al. (2007). They focus on identifying the challenges in integrating corporate social responsibility (CSR) with other strategic foci, i.e. health, safety and environment (HSE), into the supply/contractor chain. The study found that there is considerable discrepancy in the integration between suppliers/contractors and petroleum companies. The suppliers/contractors tend to focus on the technology dimension more, compared to the petroleum companies (Midttun et al., 2007). The CSR and HSE are also strategically under-communicated within the industry (Midttun et al., 2007).

Deng & Liu (2011) propose a model of GSCM for the oil industry in China. They found that there is a lack of understanding of the GSCM concept among Chinese oil companies. This finding is consistent with the study conducted by Zhu et al. (2007b) among Chinese manufacturers that also include chemical/petroleum companies in their research areas. Deng and Liu (2011) found that there are no strong initiatives by the companies to green their supply chain due to the lack of policy support. The process and technology are also inadequate, especially for energy conservation and emissions reduction (Deng and Liu, 2011).

Apart from the studies discussed above, several researchers include the O&G industry as part of the research areas in their studies. These studies focus on green purchasing/supply chain management (Min and Galle, 2001, Zhu et al., 2007b, Zhu et al., 2008b), life cycle analysis (Matos and Hall, 2007) and corporate social responsibility (Hartman et al., 2007, Zutshi et al., 2009). Among the studies, only Zhu et al. (2007b), Zhu et al. (2008b) and Matos and Hall (2007) distinguish their findings according to the researched industries.

Our review of the existing literature related to sustainability of O&G supply chain indicates that these studies are highly fragmented. Specifically, there is a lack of studies that consider the: (1) alignment of different supply chain functions and strategies towards sustainable practices, (2) external and internal factors that can affect its SSCM strategies, and (3) the joint improvement of economic, environment and social performance of supply chains.

The lack of research necessitates studies specific to the O&G industry context to enable better understanding of how the industry's external and internal environments could affect its SSCM practices. The existing literature from other industry context could help us identify possible responses to pressures from these environments. However, the appropriate strategy needed to address supply chain sustainability issues may be different for every industry and product (Halldórsson et al., 2009). Therefore, a study must be conducted to understand the relationship between contextual factors and SSCM practices in the O&G industry. This will allow us to identify supply chain solutions that are more applicable to the industry context, thus help improve its implementation of SSCM practices.

The O&G supply chain is both simpler and more complex than other industries. For instance, the product mix of O&G is more stable and static compared to, for example, car parts. However, the products are highly toxic and flammable, which causes considerable environmental and safety risks in their production and transportation processes. There are also fewer transport modes that can be used to transport the products as the distance between supply sources and consumer markets becomes larger. In addition, the logistical requirements are more complicated and risky in offshore O&G exploration and production activities because it can be affected by factors such as oil platform space availability, weather conditions and access to logistical bases. Therefore, efficient routes planning and scheduling is very important in the O&G industry. The inflexibility of O&G infrastructure and the cost-intensive nature of its activities may require that the industry focuses on improving supply chain sustainability through supplier and logistics management practices. The strategies that can be used include supplier selection based on environmental and social criteria, supplier development in quality and environmental management systems, use of multi modal transports to reduce emissions, and safety training for drivers. Companies can also employ product stewardship strategies that focus on minimizing product impacts from extraction processes to its end of life, using less polluting alternative chemicals, and on waste management.

In the next section, we propose a conceptual framework for the study of the internal and external factors that can affect the implementation of SSCM practices in the O&G industry.

2.5 Conceptual framework

This section presents the conceptual framework of this thesis. The discussion focuses on the positioning of the framework within the broader context of SSCM and O&G sustainability research.

Every company operates in a particular context that influences its strategies; companies, to a certain extent, are also able to influence this environment (Gillespie, 2011). According to Neubauer and Solomon (1977), the determinants of corporate strategy may include: (1) internal factors consisting of company capabilities and limitations, and (2) external factors including threats and opportunities in the environment and society's expectations. These factors would force a company to examine its strategic position within the environment to strengthen its competitiveness.

The suggestion made by Halldórsson et al. (2009) for studies on understanding the contextual factors of SSCM is especially relevant to the O&G industry. This is due to the

global and strategic nature of its activities and products that could heavily influence the achievement of a sustainable future. Therefore, we propose a framework that aims to shed light on the key contextual factors of SSCM of O&G. The hypothesized relationships between the factors are depicted in Figure 2.3.

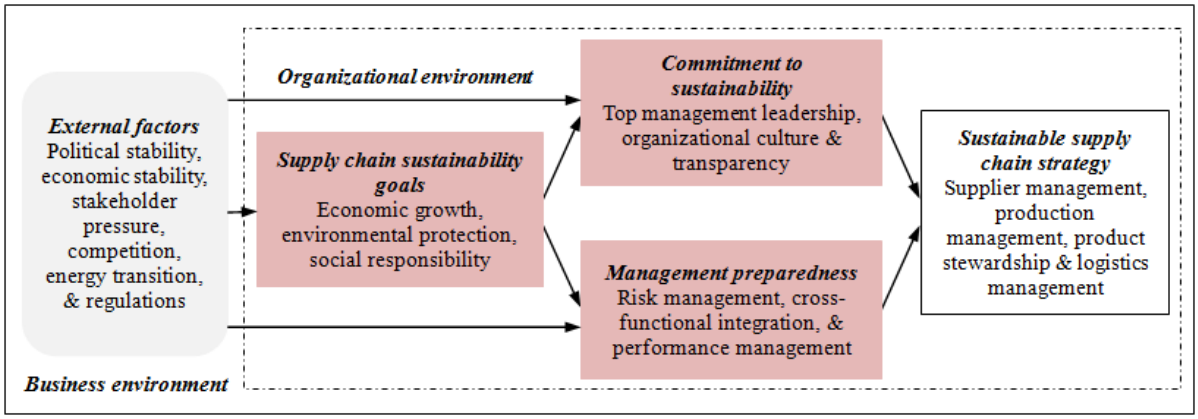

Figure 2.3 – Conceptual framework of SSCM of the O&G

The factors are categorized into external factors within the O&G industry's business environment, and internal factors that consist of organizational and supply chain function-related factors. We discuss these factors further in the following subsections.

2.5.1 External business environment

The O&G industry environment is characterized by a complex interplay of diverse environmental, socio-economic, political and regulatory settings (Wagner and Armstrong, 2010). In order to identify the forces that could influence the sustainability of the O&G supply chain, we adapt the PESTEL model, i.e. political, economic, social, technology, environmental and legal, to the context of the O&G industry's business environment. The model allows us to assess the environment in which a company operates and to identify how it could potentially affect the company's activities (Yüksel, 2012). Based on the PESTEL model and the O&G business environment literature, we distinguished the external factors into six categories, namely political stability, economic stability, stakeholder pressure, competition, energy transition and regulations.

We consider the environmental and social factors as intrinsic to the discussion of the external factors, thus they are not addressed as separate factors. The technological factor, meanwhile, is addressed through competition in the energy industry. This relates to the increased attention to the development of unconventional O&G sources and the advances in alternative energy development. In addition, we include stakeholder pressure because it is one of the most often cited external pressures for sustainable practices in supply chain (Seuring and Müller, 2008b). The final factor considered is the pressure resulting from the need to transition to low carbon energy systems to address climate change and energy security. This factor could affect the strategy that the companies in the O&G industry employ to enhance its position during the transition (Fouquet, 2010, Escobar and Vredenburg, 2011). The discussion on each of the factor selected is as follows.

a. Political stability

O&G industry operations are globally dispersed, transcending various political barriers. Due to its strategic importance, the industry is at the centre of the international geopolitical and economic landscape (Manzano, 2005). According to Pascual and Zambetakis (2008), the relationship between energy with politics is apparent in the event of crisis. There are two

sources of political risks that could affect the O&G industry. The risks could result from: (1) governmental sources related to official decisions and activities that could affect capital or profits, and (2) societal sources spurred by public interest groups that could cause unrest, civil war, industrial protest or boycotts (Iankova and Katz, 2003).

O&G reserves are concentrated in a few countries. Most of these countries depend on O&G revenues for economic development, and to some extent gain political power through their control of the reserves. Conflicts of interests in the management of local O&G company may arise due to the needs to safeguard national and, often, political interests of government (Wolf, 2009). In addition, these countries often have limited administrative capacities or a highly authoritarian political structure with weak civil societies and poor enforcement of environmental controls (Correljé and van der Linde, 2006, Sovacool, 2011, Wagner and Armstrong, 2010).

Bhatnagar and Sohal (2005) find that government's decisions and actions related to fiscal policies, protection of foreign investment, administrative efficiency and transparency are extremely important to companies' decision regarding their plant location. Similarly, a study by Urciuoli et al. (2014) on O&G supply chain resilience reveals that political instability can threaten the security of the supply chain. Conflicts resulting from the instability could lead to adverse events that can cause financial loses, ecological disasters as well as affect employee and infrastructure safety (Urciuoli et al., 2014, Al-Damkhi et al., 2009). An example is Iraq's invasion of Kuwait in 1990 (Al-Damkhi et al., 2009). This could create an uncertain business environment as the supply chain is exposed to disruption risks (Kleindorfer and Saad, 2005, Abbasi and Nilsson, 2012). The effect of instability is further worsened by choke points in oil transit routes that could be affected by how international security and conflict is handled (Pascual and Zambetakis, 2008). Correljé and van der Linde (2006) stress that it is difficult to conduct international O&G development cooperation in this unstable environment.

b. Economic stability

Many oil producing countries rely on their O&G revenue to finance development projects and subsidies (Correljé and van der Linde, 2006, Wolf, 2009). Economic slowdown will cause reduction in energy demand and price. Market risks related to the volatility of global O&G prices, exchange rates and interest rates could reduce the profitability of operations (Repsol, 2011, Petrobras, 2011). This could affect government revenue and their political will to create incentives for the development of sustainable energy and innovations (Pascual and Zambetakis, 2008).

Economic instability can also create financial risks, especially in terms of liquidity and solvency, and risks related to contractual obligations and commercial commitments with suppliers and customers (Repsol, 2011). The slowdown could affect company ability to maintain and invest in O&G development technology and infrastructure, for example in field development (Lukoil, 2011), as well as limit its ability to invest in restructuring initiatives towards low carbon energy system (Pascual and Zambetakis, 2008). Halldórsson et al. (2009) question whether a company can afford to maintain its commitment to sustainable practices during economically uncertain times.

The effect of economic instability on supply chain operations is of particular interest in studies related to its resiliency and flexibility. As companies face economic uncertainties that force them to reduce spending and downsize operations, a strategy based on scalable and variable-cost structure through strategic shared services and outsourcing practices could help the companies to minimize supply chain risks (Olson, 2010). Jüttner and Maklan (2011) found that economic recession affects demand and prices, which causes ripple effects throughout supply chains that lead to supplier insolvencies. Their study reveals that the risks involved can be mitigated through supply chain resilience capabilities such as flexibility to shift to cost-

effective supply sources and to optimize capacity utilization, supply chain visibility through information sharing, and collaboration (Jüttner and Maklan, 2011).

c. Stakeholder pressure

The external micro-environment of business consists of various stakeholders, where the relationships between these stakeholders can affect the costs, quality and overall success of a business (Gillespie, 2011). Donaldson and Preston (1995) define stakeholders are any persons or groups that may actually or potentially benefit or be harmed by firm's actions or inactions. This may include governments, investors, suppliers, political groups, communities and competitors. The level of company engagement with a stakeholder group could indicate the saliency of the stakeholder, thus the actual pressure that they exert upon the company. According to Mitchell et al. (1997), stakeholder salience depends on the power that they hold, and the legitimacy and urgency of their claim. These attributes could determine the degree to which managers prioritize competing stakeholder claims (Mitchell et al., 1997).

Stakeholder pressure is one of the most frequently mentioned drivers of SSCM in the literature (Seuring and Müller, 2008b). Companies will become more proactive towards environmental strategy when they perceive greater pressure from stakeholders (Garcés-Ayerbe et al., 2012). Increasingly more companies in the O&G industry are involved in corporate social responsibility (CSR) practices that aim to address issues such as employment, environmental protection and local community development (Frynas, 2005). Although considerable efforts are put into CSR initiatives, Frynas (2005) found that the impact is rather short-lived and philanthropic in nature due to the companies' failure to consider, among others: (1) country and context-specific issues, (2) involvement of beneficiaries of CSR, and (3) integration of CSR initiatives into overall company development plans.

The quality of the relationship with stakeholders could determine company ability to respond in a flexible way to changes in macroeconomic and market conditions, and to manage social and environmental risks (Gazprom-Neft, 2010). One of the challenges that companies have to address in building enduring and mutually beneficial relationships with stakeholders is the ability to understand stakeholders' expectations. However, the process of reaching that understanding and responding to the expectations is often difficult and confusing (Total, 2011). Factors such as inconsistent or contradictory expectations among stakeholders, and issues which are in direct conflict with business practices could add to this problem. Some of the issues that are often brought up by stakeholders with regard to the O&G industry activities include climate change, safety and environmental management, human rights and transparency.

d. Competition

According to Seuring and Muller (2008a), competition can influence a company's SSCM strategy; and the O&G industry is a highly competitive business (Wagner and Armstrong, 2010). Almost 80% of the world's oil supply comes from just three areas namely Russia, the Persian Gulf and West Africa (Xu, 2008). The growing attention on different groups of O&G companies, i.e. national O&G companies (NOCs) and international O&G companies (IOCs), indicates the broader shifts that are currently happening in the industry (Wolf, 2009, Kjärstad and Johnsson, 2009, Edwards et al., 2010). Many believe that the future competition will be between these groups, especially in terms of access to energy sources.

An increasing share of global O&G reserves is controlled by NOCs, while IOCs are facing deteriorating fiscal terms and increasing difficulty in accessing the reserves (Kjärstad and Johnsson, 2009). Cooperation between NOCs will be the norm and companies that control O&G reserves will have more power in selecting their alliance (Edwards et al., 2010). Since the O&G reserves are increasingly being controlled by a smaller number of players, supply

disruptions could occur in the absence of supportive policies, investment, as well as technology and infrastructure (Farrell and Brandt, 2006). To address the competition pressure, IOCs are putting more efforts on developing unconventional O&G sources such as from oil sands and shale O&G. These sources are more economically viable when oil price is high. This is because greater risk control is needed to reduce the environmental and economic risks, as well as strategic risks related to energy security (Farrell and Brandt, 2006).

Companies in the O&G industry are also facing more competition from the broader energy industry due to increased interest in the development of renewable and low carbon energy. Edwards et al. (2010) found that the emergence of alternative energy as among the most important external factors that could impact O&G companies in the future. Companies would be able to develop a competitive advantage over other energy players if their core values are centred on sustainability and by improving their supply chain performance (Beske and Seuring, 2014).

The current advances in alternative energy development is quite slow and cost intensive since the technology used is fairly new (Lior, 2010, Verbruggen et al., 2010). Although the energy is gaining momentum, there may be little to no pressure for the O&G industry to take the necessary actions to safeguard its position in the market due these factors. However, there might be greater focus among companies in the industry to improve the sustainability of their supply chains and their 'green competitiveness'. For example, through carbon emission reduction and energy efficiency measures that can help offset the negative attention of O&G development, thus secure their legitimacy as responsible corporate citizens.

e. Energy transition

The current energy system regime is dominated by fossil fuels, especially the O&G industry, which gives them the ability to guide decision making and direction of the energy market. However, concerns regarding unsustainable exploitation of O&G sources and energy security have increased the call for a transition to a more sustainable energy system. This transition encourages the development of renewable and low carbon alternative technology niches. During a transition process, Kemp (2010) suggests that regime actors (e.g. the O&G players) will increase their competitiveness through non-disruptive system improvement instead of system innovation to address the threat from the niches (e.g. alternative energy players). However, Pinkse and van den Buuse (2012), found that it is not unusual for an incumbent to invest in technologies that are incompatible with its core business; for example, Total and Chevron involvement in solar energy.

Our dependency on oil and gas has created technological lock-ins such as in electricity grids and transport infrastructure. In order to achieve a successful transition to low carbon energy systems, government intervention and policy supports are needed because progress in emerging energy technologies is difficult when left to be determined by the market (Roy et al., 2013). The use of transitional support for alternative energy through fiscal instruments could help in generating market forces and provide incentives for new and existing energy players to pursue low carbon energy projects (Roy et al., 2013).

Fiscal instruments could be in the form of taxes, market based instruments such as green certificates, subsidies and tax exemptions, as well as loans (Roy et al., 2013). Waisman et al. (2014) note that the policy measures used should provide correct incentives for long-term investments and incorporate sectoral measures that complement pricing scheme measures. Although this would create an uneven playing field that favours low carbon energy, it could help sectors that face biased market behaviours to have a stronger foothold in the energy market, thus help to jump start its growth. Fouquet (2010) anticipates that the O&G industry will respond to the energy transition by improving its competitiveness and making O&G sources harder to be replaced.

f. Regulations

The O&G industry activities are highly risky to the environment and public safety and health, which leaves little to no room for any incidents to occur. The Deepwater Horizon accident in 2010 illustrates the severity of an O&G industrial accident. It also exposed the lack of regulations and institutional pressure with regard to safety, health and environment (SHE) protection, in this case for offshore O&G operations (Lin-Hi and Blumberg, 2011).

Studies have found that regulatory pressure is one of the external factors that encourage the adoption of more sustainable practices in supply chains (Seuring and Müller, 2008a, Zhu et al., 2007a, Wu et al., 2012). However, the factor is also found to have the potential to inhibit novel environmental practices by lowering their competitive value (Grekova et al., 2014).

In the case of O&G industry, most companies operate in several countries with different jurisdictions and regulatory requirements. This requirements are often ambiguous and overlapping, which can cause delays and cost increases (Harris and Khare, 2002). The companies have to deal with considerable regulatory, financial and reputational risks related to legal, fiscal, safety, environment, and corporate governance (Repsol, 2011, Wagner and Armstrong, 2010). The cost of compliance with regulatory requirements varies widely and is especially financially draining for smaller companies (Harris and Khare, 2002). Since the O&G industry's activities and products are often associated with climate change and environmental problems, there could be stricter domestic and international regulations related to its products, activities and trade (Petrobras, 2011, Salter and Ford, 2000). This can also change the technical and trade requirements in supply chains, increase operating costs and reduce companies' overall competitiveness (Petrobras, 2011).

Cross-functional integration within organizations and cooperation across supply chain is needed to address the regulatory risks (Wu et al., 2012, Zhu et al., 2010, Zhu et al., 2005). For example, through purchasing practices that considers sustainability-related requirements of other departments like production, logistics and suppliers capabilities. The use of environmental management systems that enable, for instance, the assessment of suppliers' environmental performance and that track waste could also help to reduce the risks (Darnall et al., 2008).

The discussions on the O&G supply chain and its external business environment show that the industry faces considerable challenges that could affect its ability to operate sustainably. The strategy used to integrate sustainable practices in the management of O&G supply chain must enable the alignment of companies' internal organizational environment and capabilities with their external operating context. This is to ensure that the companies are able to anticipate, plan and respond to the changes in the external environment proactively. In the next subsection, we discuss these internal factors in more detail.

2.5.2 Internal organizational environment

The lack of research on SSCM of O&G necessitates the use of broader SSCM literature to help us identify the internal factors that could facilitate (or hamper) their implementation of SSCM strategy. The definitions of SSCM suggest that managerial decisions and behaviours must be directed towards achievement of economic, environmental and social goals through systemic integration of key business processes and cooperation among supply chain members. Therefore, an inventory was made of internal factors that are used by researchers to measure SSCM practices that appear frequently in the literature.

Through the analysis, a pattern emerges in which the factors can be grouped into two categories: (1) organization-related factors, and (2) supply chain function related factors. These are summarized in Table 2.4 and Table 2.5, respectively. We define the factors as

context-related because they are able to explain the organizational environment in which SSCM strategy and decisions are made in a company.

Table 2.4 – Organizational-related factors of SSCM

Factor	Item	Authors
Commitment to sustainability	Top management leadership	Zhu et al. (2008a); Faisal (2010); Hussain (2011); Wittstruck and Teuteberg (2012); Walker and Jones (2012)
	Organizational culture	Carter and Rogers (2008); Pagell and Wu (2009); Cuthbertson and Piotrowicz (2011)
	Transparency	Carter and Rogers (2008); Pagell and Wu (2009); Wolf (2011)
Management preparedness	Risk management	Seuring and Müller (2008b); Carter and Rogers (2008); Hussain (2011); Wolf (2011); Walker and Jones (2012)
	Cross functional integration	
	Strategic alignment	Carter and Rogers (2008); Faisal (2010); Hussain (2011); Walker and Jones (2012)
	Internal integration	Pagell and Wu (2009); Walker and Jones (2012);
	Cross-functional cooperation	Zhu et al. (2008a); Wolf (2011)
	Performance management	
	Performance measurement/(and) reward system linked to sustainability	Pagell and Wu (2009); Wolf (2011); Walker and Jones (2012)
	Metrics to quantify sustainability benefits in a SC	Faisal (2010); Wolf (2011)

As shown in Table 2.4, we categorized the organization-related factors into commitment to sustainability (i.e. top management leadership, culture and transparency) and management preparedness (i.e. risk management, cross functional integration and performance management). In addition to the factors shown in the table, we include supply chain sustainability goals in the conceptual framework as one of the organization-related factors. We expect that sustainability goals will determine companies' strategies to address external sustainability pressures. Porter (1991, p. 96) asserts that company success is conditioned by the development and implementation of "internally consistent set of goals and functional policies". This is necessary for the integration of the company's various functional departments towards common goals that allow the alignment of its strength and weaknesses with the threats and opportunities that are present in the external environment (Porter, 1991).

The term management preparedness is used to denote companies' capabilities in planning and implementing SSCM strategy, as well as in responding to changes in their operating environment in a timely manner. Commitment to sustainability and management preparedness are considered as organizational resources or competences that can help companies to address external pressure. These factors can consequently facilitate their adoption of sustainable supply chain practices to achieve their sustainability goals.

According to Halldórsson et al. (2009), managers face greater challenges in improving supply chain sustainability due to increased globalization of the world's economy and its negative impacts on the environment. *Top management leadership* in sustainable practices is crucial to ensure that initiatives to tackle the impacts of companies' activities are supported by the key decision-makers in an organization (Wittstruck and Teuteberg, 2012, Hussain, 2011, Walker and Jones, 2012). This commitment must be communicated to, and embraced by, all employees where sustainability becomes part of its culture (Cuthbertson, 2011). Supportive *organizational culture* and core values are important facets of SSCM because it could facilitate the implementation of sustainability strategies and initiatives (Carter and Rogers, 2008, Pagell and Wu, 2009).

Since the secrecy of corporate wrongdoings is becoming difficult and risky to maintain, many companies are disclosing their performance to stakeholders. Carter and Rogers (2008) suggest that *transparency* in SSCM includes reporting to and actively engaging stakeholders as well as using their feedback and input to improve supply chain performance. They suggest that vertical integration across supply chain and horizontal integration across networks will facilitate improvement in supply chain transparency. In addition, local optimization of environmental factors in environmental management and operations must be moved to the entire supply chain in order for the supply chain and sustainability can be converged (Linton et al., 2007). This further stresses the importance of transparency and cooperation in supply chain management in order to minimize its related risks.

Carter and Rogers (2008) defined supply chain *risk management* as a firm's ability to understand and manage its economic, environmental, and social risks. According to Kleindorfer and Saad (2005), supply chain risks include the difficulty in coordinating supply and demand, as well as disruption risks such as operational risks and risk caused by natural hazards, terrorism, and political instability. Since supply chain networks are becoming longer and clock speeds (i.e. the pace to which different supply chain parts operate) are shorter, it has resulted in the increased probability of supply chain disruptions and a smaller margin for error if a disruption occurs (Kleindorfer and Saad, 2005). Effective risk management strategy in a supply chain will enable the alignment and collaboration for risk avoidance and reduction among supply chain partners.

Seuring and Muller (2008b) found that barriers to SSCM include coordination effort and complexity, and insufficient or missing communication. *Cross-functional integration* is crucial within companies and across supply chains to address these barriers (Pagell and Wu, 2009, Walker and Jones, 2012). SSCM implies that an individual business is no longer operating solely as an autonomous entity, but rather as an interrelated and intertwined group of businesses (Chen and Paulraj, 2004, Li et al., 2006). Paulraj (2011) find that companies will be able to develop supply chain capabilities and knowledge through strategic collaboration with suppliers. This can help them to improve the sustainability of product and process design as well as to reduce cost and waste (Paulraj, 2011, Zhu et al., 2005). However, studies by Harms et al. (2013) revealed that corporate functions that are not directly connected to SSCM, for example marketing as well as research and development, may be neglected by companies in their supply chain integration initiatives. This can hinder the implementation of more encompassing cross-functional collaboration that can affect the overall performance of a supply chain (Harms et al., 2013).

Every company should also have metrics that enable them to quantify the benefits of SSCM implementation (Faisal, 2010). Effective *performance management* of the implementation can help companies to identify its business impacts and improvement opportunities. Pagell and Wu (2009) note that organizations in general are still struggling to measure the non-economic impacts of sustainability. While there are tools that can be used to measure sustainability performance, such as life cycle analysis (LCA), the application of the tools is rather limited due to the absence of formal metrics that could guide performance measurement or the lack of understanding of sustainability in organizations. Furthermore, it is difficult to monitor and measure sustainability performance and identify which sustainability initiatives contribute to performance (Zhu et al., 2007a). Nevertheless, adoption of metrics that enable such measurements should be considered to ensure effective SSCM implementation and informed decisions can be made for future initiatives. Pagell and Wu (2009) suggest that companies could also link sustainability performance with a rewards system to encourage sustainability culture and behaviour.

Table 2.5 shows the factors related to supply chain functional areas that are considered in this thesis namely supplier management, production management, product stewardship and

logistics management. The four functions are chosen because they represent the main areas in supply chain management that are involved in acquisition of new or used materials/resources, as well as in production and distribution of products/services.

Table 2.5 – Supply chain function-related factors

Factor	Construct	Authors
Supplier management	Cooperation with suppliers	Zhu et al. (2008a); Pagell and Wu (2009); Halldórsson et al. (2009); Faisal (2010); Hussain (2011); Colicchia et al. (2011); Wittstruck and Teuteberg (2012)
	Supplier certification of environmental and/or social standards	Zhu et al. (2008a); Seuring and Müller (2008b); Seuring and Müller (2008a); Pagell and Wu (2009); Halldórsson et al. (2009); Colicchia et al. (2011)
	Supplier selection, including environmental & social criteria	Seuring and Müller (2008a); Pagell and Wu (2009); Halldórsson et al. (2009); Colicchia et al. (2011); Wolf (2011)
	Information sharing	Halldórsson et al. (2009); Faisal (2010); Hussain (2011)
	Supplier audit	Zhu et al. (2008a); Seuring and Müller (2008a)
	Supplier integration & development	Seuring and Müller (2008a); Pagell and Wu (2009)
	Continuity	Pagell and Wu (2009); Wolf (2011)
Logistics management	Consolidation of shipments	Halldórsson et al. (2009); Colicchia et al. (2011)
	Choice of environmentally friendly types of transport	
	Respecting driving and resting time rules	
	Choice of environmentally friendly distribution channel	
	Reuse of transport packaging materials	
	Carrier selection	
Production management	3R of material, component parts	Zhu et al. (2008a); Halldórsson et al. (2009); Colicchia et al. (2011)
	Reduce consumption of energy/ material	Zhu et al. (2008a); Colicchia et al. (2011)
	Avoid/reduce use of hazardous product and/or their manufacturing process	Zhu et al. (2008a); Halldórsson et al. (2009)
	Elimination of waste & overuse of resources in the production	Halldórsson et al. (2009); Colicchia et al. (2011)
	Eco-efficient production	Halldórsson et al. (2009); Colicchia et al. (2011)
	Environmental management system/standards	Zhu et al. (2008a); Hussain (2011)
Product stewardship	Total-life cycle	Seuring and Müller (2008a); Pagell and Wu (2009)

Seuring and Müller (2008a) find that proactive companies are the ones who first develop sustainable products and supply chains. They emphasize that supplier development and integration should be a focus of a proactive approach to sustainability. Reactive approaches are motivated by supplier's non-conformance that could cause delay, increase costs and detrimental to achieving sustainability goals. A proactive approach to *supplier management*, for example supplier monitoring, is therefore more relevant to SSCM (Seuring and Müller, 2008a). A focus on environmental responsibility in the supply chain is also found to have led to a new approach to collaborations with suppliers, such as in environmental technology development, environmental audits and training (Kovács, 2008). These are important findings because SSCM should facilitate collaboration between supply chain partners in developing

supply chain solutions that can improve their capabilities and competitiveness (Gold et al., 2010).

As can be seen in Table 2.5, many SSCM studies concentrate on supplier management. Little attention is paid to other supply chain functions such as *logistics management*. Min and Kim (2012) examine the literature on green logistics. They note that there is a lack of research on sustainable transportation and warehousing and the life cycle assessment of logistics activities from an environmental perspective. According to Delfmann et al. (2010), logistics can contribute greatly to planning process with regard to the dynamics of the energy economy and climate protection. Climate change and energy efficiency should also be addressed by logistics and SCM professionals as convergent agendas. This is because logistics performance, as well as supply chain strategies and structure will be affected by emissions mitigation strategies, such as carbon pricing and efficient use of energy sources (Halldórsson and Kovács, 2010). The environmental burden associated with transportation activities must be considered in SSCM since it involves the distribution and discovery of new and used products (Tsoulfas and Pappis, 2008).

Besides logistics, there are numerous ways in which the sustainability of supply chain can be influenced by *production management* strategies (Sarkis, 2003). This includes the capability of the processes to use certain materials, integrate reusable or remanufactured components and prevent waste (Sarkis, 2003, Tsoulfas and Pappis, 2008). The strategy used in a production activity can also affect other supply chain functions. For example, product packaging, such as in terms of size, shape and materials, has a strong relationship with logistics (Sarkis, 2003).

A study was conducted by French (2008) on the reuse of product returns in chemical blending business. The study reveals that companies are concerned about the additional cost of this strategy, such as to provide tracking system and extra labour to handle and process returned products. However, the companies can benefits from reusing "free products" that remain in the returnable container in the blending process, thus help to eliminate waste and reduce disposal cost (French, 2008). In addition, the use of this strategy could also reduce the customer burden to dispose the surplus product and its containers (French, 2008).

The life cycle of products should be taken into consideration as early as during the design process to minimize its negative impact to the environment (Srivastava, 2007). LCA is a decision-making tool that is developed for the integration of environmental concerns throughout a supply chain. Matos and Hall (2007) found that LCA can be applied for companies operating under different circumstances and approaches in SSCM practices. The managerial challenge in implementing LCA, thus ensuring *product stewardship*, is in exploring the interdependencies of the parameters used to measure sustainability and the broader sustainable development concerns of society (Matos and Hall, 2007).

In this section, we propose a conceptual framework that operationalizes the contextual factors within the O&G industry's business and organizational environments that could influence its implementation of SSCM practices. In the next section, we will discuss the conceptual framework from organizational perspectives; specifically, its linkages with institutional theory, stakeholder theory and dynamic capabilities theory.

2.6 Interpretation of the conceptual framework from the perspectives of organizational theories

Sarkis et al. (2011, p. 2) defined organizational theory as "a management insight that can help explain or describe organizational behaviours, designs, or structures". In the context of this

study, the theory can be used to understand companies' responses to internal and external sustainability pressures in their implementation of SSCM practices. We focus our discussions on three complementary organizational theories: institutional theory, stakeholder theory and dynamic capabilities theory. Institutional theory and stakeholder theory can help us explain how companies respond to external pressures. Dynamic capabilities theory, on the other hand, can help us describe how organizational capabilities or resources can facilitate companies' adoption of sustainable supply chain strategies.

While other theories such as complexity and relational theory can also address the diverse environmental factors that can influence, for example, how companies harness their relationship with suppliers to improve supply chain sustainability (Sarkis et al., 2011, Zhang and Aramyan, 2009), they only cover a small part of the focus of this study. We think that the three theories chosen are sufficient in helping us validate our position regarding the relationships between the contextual factors and SSCM practices proposed in the conceptual framework.

According to institutional theory, every company operates within an organizational field comprising of institutional forces such as political, economic, key suppliers, consumers, regulatory agencies, competitors, social or industry norms that could affect its business strategy (DiMaggio and Powell, 1983, Scott, 2005). These forces can create coercive (e.g. from regulators, government), mimetic (e.g. from competitors) and normative (e.g. from professional associations or industry norms) pressure that can shape organization behaviours, forms and processes (DiMaggio and Powell, 1983). Organizational responses to the pressure are isomorphic in nature when faced with similar institutional pressure (DiMaggio and Powell, 1983). Oliver (1991), however, argues that firm's responses to the pressure vary. Based on the resource-dependency argument, Oliver (1991) posits a variety of firm's strategic responses to institutional pressure. The responses may be driven by active organizational behaviour and interest-seeking nature of the organization in its attempt to obtain stability and legitimacy. Apart from the most likely response of conformity, organizational response to the pressure could be in the form of compromise, avoidance, defiance and manipulation, which depends on the nature and the context of the pressure (Oliver, 1991).

We proposed that institutional pressures resulting from economic and political conditions, regulatory requirements, competitions, and policies to spur energy transition can influence supply chain sustainability goals of companies in the O&G industry. Companies' responses to the pressure will determine their focus on the goals, and eventually the SSCM strategies that are used to achieve them. Wu and Pagell (2011) and Giunipero et al. (2012) found that regulatory pressure can increase companies' adoption of sustainable supply chain practices. However, Escobar and Vredenburg (2011) note that isomorphic coercive, normative and mimetic response to sustainable development pressure is unlikely among multinational O&G companies. This may be attributed to the differences in international regulatory and enforcement mechanisms, subsidiaries' interpretation of sustainable development, and a lack of a sustainable business model or best practices that can be easily acquired and duplicated across the industry (Escobar and Vredenburg, 2011). Based on this argument, we can assume that the relationships between external factors and supply chain sustainability goals in this study will vary – companies respond to the factors by focusing on the goals that can best secure their interests.

This response can be illustrated by Wu et al. (2012)'s findings that competitive pressure has a negative influence on sustainable supply chain practices, which is in contrast to their initial prediction. They attributed this finding to the difficulty of inter-supply chain imitation (i.e. mimetic response) of competitor's sustainability strategies. In the previous section, we argue that competition from within the O&G industry and from the broader energy industry players can affect O&G companies. Based on Wu et al. (2012)'s findings, we can assume that

the O&G industry's responses to competitors will also vary depending on the type of competition. For instance, competition from within the O&G industry may result in mimetic responses towards achieving their sustainability goals. Competition from alternative energy companies, on the other hand, may result in avoidance or manipulation (i.e. less focus on environmental goals and higher focus on economic goals to reduce the competition) due to the O&G industry inability to compete based on, for example, carbon emissions management strategies of the alternatives.

While institutional theory describes how institutions influence organizational behaviour and decisions to create institutional rules, stakeholder theory, on the other hand, concerns groups and individuals that can affect or can be affected by organization actions; about managerial behaviour as they interact and build relationship with groups and individuals to create value (Freeman et al., 2004, Donaldson and Preston, 1995). Mitchell et al. (1997) proposes three attributes that determine stakeholder saliency, i.e. the degree to which managers prioritize competing stakeholder claims, namely power, legitimacy and urgency. For example, a stakeholder may have legitimate claims on a company, such as a local community who is concerned about safety and health effects of unconventional O&G development close to homes, and has urgent needs for the company to address the claims. However, the community may be sidelined due to a higher priority given to less legitimate and/or less urgent claims from stakeholders that have more power to negotiate their claims. Based on this argument, we assume that the level of stakeholder involvement in decision-making processes at strategic level reflects the saliency of each stakeholder group. This can be used to gauge the actual level of pressure that they exert upon companies, which will influence the supply chain sustainability goals that the companies pursue. Lee (2011) and Wu et al. (2012) argue that institutions and stakeholders are interdependent, and together they could determine how organizations develop their strategy to respond to external influence and achieve their sustainability goals.

SSCM literature rarely includes sustainability goals as an explicit and distinct factor that can affect strategy formulation or can be affected by factors within the business and organizational environment. Instead, it is often assumed as part of the outcome or the end motives of SSCM practices, which is to achieve a balanced economic, environmental and social performance. Azzone and Noci (1998) find that linking sustainability goals and measures to corporate strategy can facilitate the integration of sustainability into an organization's activities. The goal of sustainability programs must be defined during their design stage (Hervani et al., 2005), and must be integrated into day-to-day supply chain management activities (Pagell and Wu, 2009). These studies point out the role of sustainability goals as a foundation on which SSCM strategy is built. Following these findings, we therefore view sustainability goals as a moderating factor that could intensify or reduce the influence of the external pressure on the adoption of sustainable supply chain practices in the O&G industry. The sustainability goals, in turn, would determine the organizational resources and capabilities that companies develop towards addressing the sustainability pressure in supply chain management.

Escobar and Vredenburg (2011) find that the development and acquisition of resources and capabilities among O&G companies are dependent upon the sustainability pressure that their external environment exerts on the companies. This can consequently determine their corporate sustainable development strategy. Teece et al. (1997) define dynamic capabilities as a firm's ability to sense, seize and reconfigure itself in order to develop and exploit internal and external competences, as well as adapt to and shape its environment. Eisenhardt and Martin (2000, p. 1107) suggest that dynamic capabilities are "the organizational and strategic routines by which firms achieve new resource configurations as markets emerge, collide, split,

evolve, and die". The theory assumes bounded rationality and profit seeking, but not necessarily profit-maximizing, behaviour (Augier and Teece, 2009).

According to Beske (2012), the application of dynamic capabilities theory is relevant to the SSCM field since both share similar environmental and organizational conditions that allow companies to adapt to changing environment and pressures. In this study, we proposed that commitments to sustainability (i.e. top management leadership, organizational culture and transparency) and management preparedness (i.e. risk management, cross-functional integration and performance management) build on firm-specific dynamic organizational resources (e.g. knowledge, experience and values) and competences. These factors enable companies to sense the changes, threats and opportunities that exist in their external environment, seize the opportunities, as well as reconfigure themselves to adapt to the changes, exploit the opportunities and overcome the threats. These resources and capabilities would determine how sustainable practices can be integrated into various supply chain functions within companies' boundaries and extended into supply chain partners' practices (Pagell and Wu, 2009, Seuring and Müller, 2008b, Zhu et al., 2008a).

Reuter et al. (2010) observe that external pressure and internal capabilities have path dependency relationships with sustainable supplier management strategy. Specifically, they find that internal integration enables companies to develop sustainable supplier management capabilities faster and with fewer resources than competitors. In addition, companies responses to competition depend on the availability of internal resources and intensity of external pressure (Reuter et al., 2010). These findings are in line with the causal relationship proposed in our conceptual framework regarding the influence of external and internal factors on companies' adoption of sustainable supply chain strategy.

The above discussions allow us to link the conceptual framework proposed in this thesis to three organizational theories. Table 2.6 summarizes the linkages between the framework and the theories. While we cannot possibly capture all of the elements, assumptions and relationships that underpin the three theories in the framework, insights gained from the theories provide multidimensional perspectives to our study. Specifically, it supports the notion that SSCM strategy is an outcome of the interplay between factors within organizational and business environments, as well as companies' interaction with the environments. Therefore, we conclude that the framework is in agreement with the main conceptualization of the theories.

Table 2.6 – The linkages between conceptual framework of thesis and organizational theories

Theory	General conceptualization	Implications (necessary elements)
Institutional theory	• Firm's external environments consist institutional forces that create coercive, normative and mimetic response to pressure; • Early institutionalists stress conformity and isomorphic behaviour among firms that operate in similar institutional context, but later studies posit that firm's response vary, where organizational choice is possible and may be interest-driven in its attempt to obtain stability and legitimacy.	• Political and economic stability, regulations, competition and the transition to low carbon energy systems create sustainability pressures that have positive relationship with companies focus on supply chain sustainability goals and, consequently, their commitment and preparedness to adopt sustainable supply chain strategy.
Stakeholder theory	• Firm produce externalities that affect internal and external parties (i.e. stakeholders), the stakeholders can in turn pressure the firm to increase positive impacts and reduce negative impacts; • Firm's responses to stakeholder pressure and which stakeholder to prioritize depends on stakeholder power, urgency and legitimacy.	• Stakeholder pressure has a positive relationship with sustainability goals that companies in the O&G industry pursue, which in turn determines the internal capabilities and supply chain strategy that they use to achieve the goals.
Dynamic capabilities	• Firm's ability to sense, seize and reconfigure itself in order to develop and exploit internal and external competences, as well as adapt to and shape its environment; • Managers are assumed to be boundedly rational and profit seeking.	• Commitment to sustainability and management preparedness comprise of unique organizational resources and competences that can support the development and implementation of sustainable supply chain strategies; • Proactive approach to addressing sustainability pressure and adapting to changes in external environment through commitment to and preparedness for sustainable practices are dynamic organizational capabilities and resources that must be nurtured and harnessed; • These capabilities and resources have positive relationship with companies' implementation of sustainable supply chain strategies

2.7 Discussion and conclusion

This chapter presents a conceptual framework of key contextual factors of SSCM practices in the O&G industry. Currently, there is a lack of research on SSCM in the O&G industry from a multidimensional point of view. In addition, existing studies are fragmented, where none incorporates economic, environmental and social dimensions of sustainable development, as well as study all the stages in the O&G supply chain. In addition, frameworks are lacking in terms of the contextual aspects of the industry's business and organizational environment. This thesis suggests an overarching framework operationalizing these factors to address the gap. A systemic view of SSCM practices in the O&G industry is needed in order to understand: (1) how the industry addresses the pressure to operate sustainably throughout its

supply chain, and (2) how the contextual factors of its operating environment influence its SSCM strategy.

Since every company within the O&G industry belongs to various supply networks, there exist interdependencies between the companies as their paths cross. In order to understand the network, we need to understand its individual members, as each company is operating within its own context and engages in the network through its localized decision-making process (Surana et al., 2005). This will eventually help us identify and understand the O&G industry's collective behaviour in its SSCM practices.

From a scientific perspective, this study is of value to researchers who are interested in understanding sustainability-related issues in the supply chain of O&G. It incorporates both the internal and external contextual factors of the O&G industry's operating environment that can influence its SSCM practices in four supply chain functional areas: supplier management, production management, logistics management and product stewardship. From a managerial perspective, the proposed framework can help O&G companies to assess their contextual environment, which is key to formulating an effective SSCM strategy. It can, therefore, be used as a tool in decision-making processes to improve supply chain sustainability through: (1) an analysis of the key business and organizational factors that can play a role on SSCM practices; and (2) the development of more effective management measures and capabilities according to organizational operating context. The framework is also useful for identifying and interpreting differences between SSCM practices of companies operating in different contexts.

In the next chapter, we present the results of a content analysis of sustainability reports of O&G companies. The analysis was conducted to gain an overview of sustainable practices among companies in the O&G industry. Specifically, we examine the extent of companies reporting of their intention (commitment to) and performance in sustainable practices. In addition, we analyze the strategies that the companies used in integrating sustainability dimensions in their supplier management, product stewardship and logistics management practices.

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3. A Review of Sustainability Reporting Practices in the Oil and Gas Industry

This chapter is based on: Wan Ahmad, W.N.K., de Brito, M. and Tavasszy, L.A. (2016), "Sustainable supply chain management in the oil and gas industry: a review of corporate sustainability reporting practices", Benchmarking: An International Journal, Vol. 23 No. 6, pp. 1423-1444.

3.1 Introduction

The strategic importance of public disclosure of sustainability performance is increasingly recognized by companies amid greater demand for transparency in their business activities. This is evident in the growing number of oil and gas (O&G) companies that publish sustainability reports over the years. While Shell and BP started to publish the report in 1998, Saudi Aramco and Gazprom produced their first report in 2010.

Sustainability reports help stakeholders learn about companies' sustainability initiatives and performance, and the strategy used to address sustainability pressures. Despite a growing interest from academics and practitioners on these reports, studies that focus on supply chain related aspects are still lacking (Tate et al., 2010). Furthermore, research evaluating industry-specific practices is also scarce. The lack of research on sustainable supply chain management (SSCM) in the O&G industry necessitates the use of sustainability reports to gain an overview of its practices. This also helps to identify improvement opportunities in current practices that can facilitate the implementation of SSCM in the industry.

This chapter aims to address these research gap through a review of sustainability reporting practices in the O&G industry. Specifically it focuses on the following questions:

1. *To what extent do companies in the O&G industry communicate their commitment and performance related to sustainable practices?*
2. *What are the sustainable supply chain strategies adopted by companies in the O&G industry?*

The review is accomplished through a content analysis of sustainability reports of 30 major O&G companies. For the first research question, we focus on *intent* related indicators (i.e. commitment expressed towards sustainability practices such as environmental policy and vision) and *performance* related indicators (e.g. emissions and, health and safety incidents). The discussions on the second research question focus on the integration of sustainable practices in three key supply chain areas namely supplier management, product stewardship and logistics management. Production management strategy is not included separately in our discussions of the second research question. This is because the content analysis instrument used in this study contains several indicators that assses this area; for example, in terms of waste management, as well as water and energy use.

This chapter is organized as follows. Section 3.2 presents an overview of the literature related to sustainability reporting. Section 3.3 explains the methodology for the content analysis. It is followed by Section 3.4 that discusses the results of the analysis. We draw conclusions in Section 3.5.

3.2 Overview of sustainability reporting studies

The importance of SSCM practices in the O&G industry was reaffirmed in the wake of the Deepwater Horizon oil spill in the Gulf of Mexico. According to Janus and Murphy (2013) companies are now expected to disclose their plans and initiatives to address sustainability issues of their internal business processes as well as suppliers' activities. However, they note that there is a lack of guidance in the reporting field regarding the measurement and communication of these practices with regard to supply chain management. The fourth generation of sustainability reporting guidelines by the Global Reporting Initiatives (GRI) attempts to address this issue (GRI, 2013).

Table 3.1 summarizes some sustainability reporting studies related to the O&G industry and/or SCM. Generally, the review of the literature indicates that most of the studies focus on the environmental aspects of sustainability, while little attention is paid to social sustainability (see for example, Freedman and Jaggi (2005), Jose and Lee (2007) and Clarkson et al. (2010)). The number of studies related to sustainability reporting of O&G companies increased during the latter period of the review. The majority of studies, however, are focused on the reporting practices of various industries. Studies that examine the reporting practices of multiple industries may be able to identify best practice examples that can be applied across industries. Industry-specific studies, on the other hand, would likely result in knowledge that is more applicable and, therefore, more useful to that particular industry context.

Context specific studies are important because sustainability may be viewed differently by different industries depending on their business model, inputs, outputs and customer base (Azapagic, 2003, Cowan et al., 2010). Meckenstock et al. (2015) found that the interpretation of sustainability is different across supply chain echelons. Specifically, companies that operate in downstream supply chains will emphasize the complexity of implementing sustainable practices more in their reports than upstream companies due their increased attention to external stakeholders and 'proximity' to end consumers (Meckenstock et al. 2015). Furthermore, various contextual factors could influence sustainability disclosure such as regulatory requirements as well as the degree and level of institutionalization of sustainability in local business environment (Bell and Lundblad, 2011). The content of sustainability reports, therefore, could vary widely (Asif et al., 2013). For example, companies that operate in the countries that ratified the Kyoto Protocol for pollution management have higher disclosure indices compared to companies from other countries (Freedman and Jaggi, 2005). The cultural and socio-economic environment in which a

company operates can also influence the extent of its reporting practices (Fifka and Drabble, 2012).

Table 3.1 – Sustainability reporting studies related to oil and gas and/or supply chain

Author(s)	Year	Focus area of disclosure	Type of firm selected
Freedman and Jaggi	2005	Pollution and greenhouse gases	Largest public firms in O&G, chemical, energy, and motor vehicles and casualty insurers
Jose and Lee	2007	Environmental policies and practices	Fortune Global 200 companies
Clarkson et al.	2008	Environmental performance and disclosure practices	Five most polluting industry in the United States (US)
Cowan et al.	2010	Environmental sustainability reporting (also include leadership, assurance, certification and method of reporting)	Five largest companies of 26 industrial sectors in the US
Dong and Burritt		Quantity and quality of social and environmental reporting against general and industry's benchmark	Australian O&G companies
Morali and Searcy		Integration of sustainability criteria in SCM	Canadian companies
Tate et al.		Integration of sustainability into operations and SCM strategies	Companies from eight industries
Bell and Lundblad	2011	Comparison of ExxonMobil sustainability reporting to outcome over 7 years	A case study in ExxonMobil (EM)
Wu et al.	2012	Integration of green concepts and practices in SCM	Fortune Global 500 companies
Fifka and Drabble		Influence of contextual factors on sustainability reporting	50 largest companies in United Kingdom and Finland
Alazzani and Wan-Hussin	2013	Environmental performance reporting	Eight O&G companies operating in developing countries
Asif et al.		Patterns of sustainability reporting (includes SCM indicators)	Dutch companies
Schneider et al.		Evaluation of the maturity of environmental,, health and safety practices	Ten major oil companies
O'Connor and Gronewold		Discourse in communication of environmental sustainability strategy and performance	Fortune Global 500 petroleum companies
Thurner and Proskuryakova		Changes in the approaches to environmental management	Six Russian O&G producers
Fernandez-Feijoo et al.	2014	Effect of stakeholder pressure on transparency of sustainability reports	Various industries that report based on GRI framework (including energy)
Herremans et al.	2015	Stakeholder engagement strategy through sustainability reporting practices	All major O&G companies in Canada
Meckenstock et al.		Effects of differences in interpretation of sustainability on SSCM strategy	Twelve industries including the O&G

Tate et al. (2010) stress that corporate social responsibility reports are a rich source of secondary data that could help us understand companies' intentions, strategies and activities. Following this, we argue that understanding the sustainability reporting practices of companies in the O&G industry constitutes an important step in advancing the integration of sustainability in their supply chains. As can be seen in Table 3.1, there are seven studies on the sustainability reporting of O&G companies. Generally, these studies are either country-specific (Dong and Burritt, 2010, Thurner and Proskuryakova, 2014, Herremans et al., 2015), focus on one facet of sustainability, i.e. environmental aspects (O'Connor and Gronewold, 2012, Alazzani and Wan-Hussin, 2013, Schneider et al., 2015), or a case study on one company (Bell and Lundblad, 2011).

Dong and Burritt (2010) found that the reporting of social and environmental sustainability among the O&G companies that they studied is internally focused and under-reported relative to the industry guideline. There is also a lack of information that could help stakeholders assess companies' performance objectively (Schneider et al., 2015, Dong and Burritt, 2010). In addition, companies tend to express their commitments towards environmental sustainability, but fail to develop a system that could help them fulfil the commitments (Jose and Lee, 2007).

These finding are consistent with Bell and Lundblad (2011) study on the reporting practices of ExxonMobil. They also found that the company's earlier sustainability reports mainly serve as a tool to improve its corporate image and legitimacy. Institutional pressure and increased incorporation of external guidelines, however, has improved its reporting practices over the years.

According to O'Connor and Gronewold (2013), companies within the refining industry approach environmental sustainability discourse based on competitive advantage and institutional logics. The companies address regulatory and stakeholder pressures through their reporting, while positioning themselves, for example, as an industry leader or first mover in sustainable practices and performance. Thurner and Proskuryakova (2014) find that companies' voluntary actions and initiatives can be the main driver for the adoption of sustainable practices because it can help them gain competitive advantage in the market.

The quality of sustainability reporting could improve as companies respond to stakeholder pressure (Fernandez-Feijoo et al., 2014). Tate et al. (2010) suggest that companies use sustainability reports to manage institutional pressure so as to meet stakeholder demands. In order to address the pressure, the companies must develop a strategy that incorporate various sustainability issues in their strategic and operational plan (Hervani et al., 2005). Their engagement with the stakeholders through sustainability reporting could either be informing, responding or involving; it depends on companies' dependency on the resources controlled by the stakeholders (Herremans et al., 2015). However, companies could neglect to report the information that is relevant to certain stakeholders, such as communities and consumers, thereby undermining the credibility of their reporting practices (Dong and Burritt, 2010).

With regard to SCM aspects, Tate et al. (2010) note the lack of research on understanding the communication of social and environmental aspects related to companies' operations and supply chain strategies. Sustainability reports provide readily available data that can help us understand how sustainability is being addressed in operations. A similar view comes from Rabinovich and Cheon (2011), specifically with regards to the use of secondary data sources in understanding logistics and supply chain phenomena. Results obtained from these data sources can be more relevant for practical managerial applications especially when the data are collected from the field (Rabinovich and Cheon, 2011).

Table 3.1 indicates that there are four supply chain-related studies, which are generally about the integration of sustainability into supply chain management (Wu et al., 2012, Tate et al., 2010, Morali and Searcy, 2010, Meckenstock et al., 2015). According to Meckenstock et al. (2015), there is an increased emphasis on the reporting of social complexity in SSCM as a company operates further downstream in a supply chain closer to the final consumers. The complexity of integrating sustainability in SCM is amplified by the difficulty in operationalizing a shared interpretation of sustainability across the supply chain (Meckenstock et al., 2015). This, in turn, could hinder the implementation of SSCM strategy.

SSCM seeks to achieve a joint optimization of business processes to ensure sustainable economic, environmental and social performance of all supply chain members. Therefore, individual companies no longer operate as autonomous entities, but as an intertwined group of businesses that can determine the overall performance of a supply chain (Li et al., 2006).

The existing literature on the reporting of sustainable supply chain practices reveals that companies, in general, discuss their strategy for addressing the sustainability issues at the strategic level (Morali and Searcy, 2010). Even though companies are mainly focusing on cost reduction and pollution prevention, they are beginning to incorporate more proactive measures in the management of their supply chains (Wu et al., 2012). While there is apparent increase in the attention given to the supply chain sustainability, major improvements are still needed in the extensiveness of the disclosure of the implementation and performance of the strategy (Morali and Searcy, 2010, Wu et al., 2012).

Based on the literature discussed, it is apparent that there is a lack of studies that focus on both the sustainability reporting practices and integration of sustainability in SCM practices in the O&G industry context. In this chapter, we address these gap by: (1) focusing on the sustainability reporting of global O&G companies, (2) assessing the intent for and reporting of performance related to sustainable practices in the environmental and social dimensions, and (3) identifying the strategies used to integrate sustainability in the companies' supply chain management practices.

3.3 Methodology

In this section, we describe the methodology used to conduct the content analysis of sustainability reports of O&G companies.

3.3.1 Company selection

We used three listings to identify the companies that can be selected for the content analysis. The listings are: (1) the 2011 Dow Jones Sustainability Index (DJSI), (2) The Oil & Gas Journal's world's largest O&G company ranking (based on total reserves, OGJ), and (3) Platts top 250 global energy company ranking 2011 (based on economic performance, Platts). Overall, we identified 80 O&G companies through the listings, where 30 companies that publish sustainability reports were selected using a purposive sampling method. This method allows us to select companies based on their sustainability performance, financial performance and size. Table 3.2 shows the selected companies.

Table 3.2 – List of companies selected according to listings

	Companies listed in:			Total	
Group	**Dow Jones Sustainability Index**	**Platts Top 250 Global Energy Company**	**World's Largest O&G Company**		
A	Repsol, Petrobras, Ecopetrol, BG Group, Eni, Statoil and Total			7	7
B	MOL and Sasol			2	14
		Hess, Exxon Mobil, BP, Shell, Gazprom Neft, Occidental, Gazprom, Chevron, Rosneft, Lukoil, PetroChina and Suncor		12	
C		CNPC, TNK-BP, Marathon Oil, OMV, Husky Energy and Galp Energia		6	9
			Saudi Aramco, ADNOC and Petronas	3	

The following procedure was adopted for the selection. First, the companies which are listed in all three listings were chosen (7 companies). Then, it was followed by those which are listed in two listings. Initially, 15 companies were found in this category. However, one company did not publish a sustainability report. We removed the company, thus only retained 14 companies from the group. The remaining companies were selected based on their

positions in the listings and sustainability report availability.

We used the latest reports available for the content analysis purposes. Overall, the latest sustainability reports published during the period in which this study was conducted were from the following year: 2009 (two companies), 2010 (25 companies) and 2011 (three companies). We grouped the companies into:

- Group A: companies are listed in all three listings (triple-listed companies);
- Group B: companies are listed in any of two listings (dual-listed companies);
- Group C: companies are listed only in one listing (single-listed companies).

3.3.2 Content analysis

This study used a questionnaire developed by Roberts Environmental Center (REC) as a benchmark to assess the sustainability reporting of the O&G companies selected (REC, 2010). The questionnaire, Pacific Sustainability Index (PSI), was chosen due to the extensiveness of sustainability measures included. The index was developed by REC to study the reporting of sustainability intention and performance. The questions included in the index are based on frequently mentioned topics that REC researchers discovered through their analysis of 1900 reports from 2002 to 2009. The index is considered as very suitable to be used as a tool for this study, given that it was developed after a long period of research.

Table 3.3 shows the indicators that are used by the PSI to measure companies' intention to sustainable practices and the reporting of performance related measures. The index uses 84 indicators to measure sustainability intention and performance reporting. Environmental and social intent are expected to be incorporated into 13 indicators, while environmental reporting and social reporting are expected to appear in the reports through 32 and 26 indicators, respectively.

Intentions towards sustainable practices were measured based on commitment-related indicators which can be categorized into five topics: accountability, management, policy, vision and social demographics (measured in social intent only). The performance reporting on the other hand was measured using the following indicators: (1) environmental reporting – such as water and air emissions, energy and water use, investment, prevention and recovery programs, and waste management; (2) social reporting – such as human rights protection initiatives, safety and health performance, and community development initiatives and investment.

The content analysis involved keywords search based on the description of each indicator specified in the questionnaire; for example, keywords for accountability include "management structure" and "contact person" (please refer to Appendix I for more details regarding how to identify each indicator in sustainability reports). Apart from understanding companies' intention towards sustainable practices and reporting of sustainability performance, we could also obtain an overview of the sustainability issues discussed in the reports. This could indicate the kind of issues that are important for the companies studied. We collected nominal data in the content analysis, i.e. a score of 1 was given if a report disclosed information related to an indicator, while a score of 0 was given if the information is absent from the report. The method used is similar to a study conducted by Perez and Sanchez (2009).

Table 3.3 – The Pacific Sustainability Index topics

	Environmental topics	Indicators	Social topics	Indicators
Intent	Accountability	Report contact person, environmental management structure	Accountability	Health & safety, or social organizational structure, third party validation
	Management	Environmental education, environmental management system, environmental accounting, stakeholder consultation	Management	Workforce profile (i.e. ethnicities/race, gender & age), emergency preparedness program, employee training for career development
	Policy	Environmental policy statement, climate change/global warming, habitat/ecosystem conservation, biodiversity, green purchasing	Policy	Social policy statement, code of conduct or business ethics, supplier screening/supplier management
	Vision	Environmental impediments & challenges, environmental visionary statement	Vision	Social visionary statement, social impediments & challenges
			Social demographic	Employment for individuals with disabilities
Performance	Emissions to air	Total GHG (or CO2 equivalents), CO2 or equivalents (i.e. GHG), volatile organic compounds (VOCs), methane (CH4), sulphur hexafluoride (SF6), carbon monoxide (CO), nitrogen oxides (NOx), VOC concentration, particulate matter (dust), sulphur oxides (SOx)	Human rights	Sexual harassment, political contributions, bribery, anti-corruption practices, degrading treatment/punishment of employees, elimination of discrimination in respect to employment and occupation, free association and collective bargaining of employees, fair compensation, elimination of all forms of forces & compulsory labor, reasonable working hours, effective abolition of child labor
	Emissions to water	Suspended solids (total TSS), biochemical oxygen demand (BOD), emissions to water (total, including fuel spillage or leakage)	Management	Women in management
	Energy	Total energy used, total renewable energy used	Qualitative social	Community development, employee satisfaction surveys, community education, occupational health & safety protection, employee volunteerism, access to health care for employees
	Management	Notices of environmental violation, environmental expenses and investments, fines, green technologies research & development, protection of marine ecosystems, recovery of spilled fuel, pipeline monitoring & maintenance, accidental spills		
	Materials usage	Life cycle analysis (LCA)	Quantitative social	Employee turnover rate, recordable incident/accident rate, lost workday case rate, health & safety citations, health & safety fines, social community investment, fatal injuries, serious injuries
	Recycling	Solid waste, office waste, wastewater		
	Waste	Solid waste disposed off, hazardous waste produced & released to the environment, wastewater released to natural water bodies		
	Water	Water used		

Although the questionnaire is adequate in measuring sustainability disclosure in general,

the same cannot be said for the supply chain sustainability aspects since there are limited supply chain indicators in the index. Therefore, an additional keywords search was conducted, leading to those listed in Table 3.4. This process enabled us to identify organizational patterns specific to SSCM practices in the O&G industry context.

Table 3.4 – Supply chain management related keywords

Topic	Keyword
Supply chain	Supply, chain, network, partners
Supplier management	Suppl*, management, development, collaboration, purchasing, procurement, local,
Product stewardship	Prod*, life cycle, material*, REACH, chemicals, end use, quality
Logistics	Logistics, transport*, vehicles, mode, routes, suppl*, warehous*, fleet, vessels, journey, distribut*, network, storage

* Indicates the keyword and its variants, e.g. transport*, transportation etc.

Data gathered through the PSI questionnaire were analyzed quantitatively, while statements related to SSCM practices among the companies were analyzed qualitatively to isolate and describe its patterns. We calculated the score for each topic and the score for environmental and social intent and reporting as the percentage of indicators discussed – i.e. the score is calculated by dividing the number of indicators discussed in the report by the total number of indicators. Hence, the maximum score for the topics and the overall sustainability intention and reporting is always 1, or 100%. The score calculation is based on the assumption that each indicator carries the same weight. For instance, if 10 indicators correspond to the reporting of air emissions, a company reporting only two of those indicators will get a score of 0.2 on this topic. Our score calculation method resembles Perez and Sanchez (2009) study on the assessment of sustainability reporting evolution in the mining industry. The next section presents the results of the content analysis.

3.4 Results and analysis

As mentioned earlier, we selected the companies using three listings which enable us to categorize them into three groups: Group A (triple-listed companies), Group B (dual-listed companies) and Group C (single-listed companies). We discuss the results of the content analysis according to the research questions posed in Section 3.1.

3.4.1 Sustainability intention and reporting

Figure 3.1 shows the difference in the disclosure of intention and performance between the three groups.

Generally, the sustainability reporting of the companies in Group A is more extensive than the other groups, both in terms of disclosure of intention and performance. The companies in Group A reported, on average, 69% of the indicators compared to 55% (Group B) and 52% (Group C). As can be seen in the Figure 3.1, it is clear that most companies generally covered environmental intent indicators more extensively than social intent. However, the active reporting of environmental performance is lagging behind social performance contrary to the intention disclosed in the reports. Overall, only Group A is consistent in their reporting practices – their social intent is higher than environmental intent and they also reported more on social performance than environmental performance.

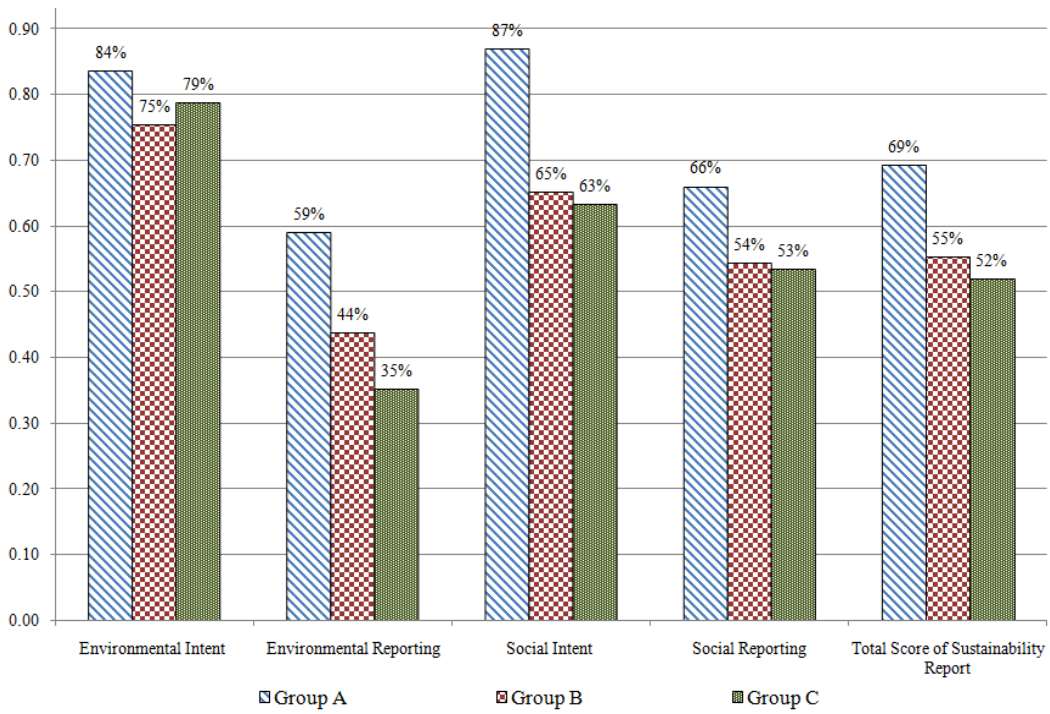

Figure 3.1 – Comparison of sustainability disclosure between groups

a. Environmental intent and reporting

Figure 3.2 shows the disclosure of environmental intent and performance reporting according to their topic categories.

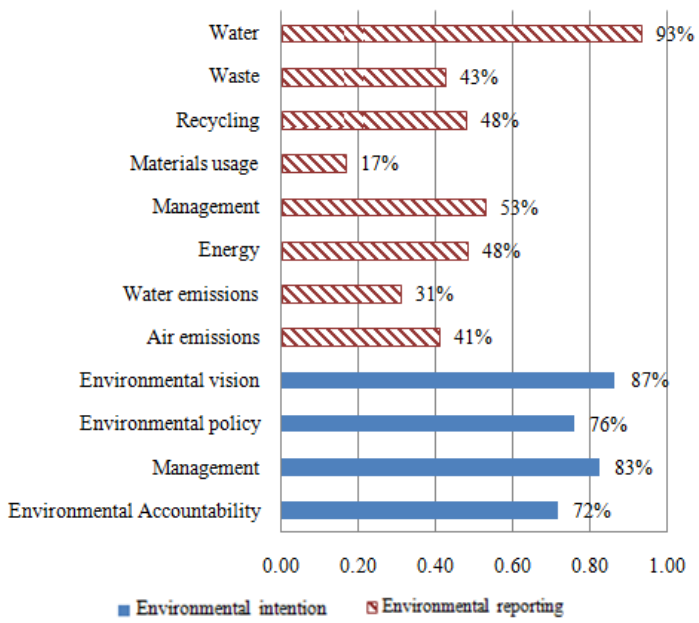

Figure 3.2 – Environmental intent and reporting disclosure score

Two indicators were used to measure environmental accountability, namely the disclosure of a contact person, and company's environmental management structure. Generally, 70% of the companies identified specific persons and/or provided the information on how they can be contacted regarding their reports or sustainability issues. About 73% of the companies reported their environmental management structure and the staff or functions responsible for the development of environmental policies and initiatives.

All companies noted the importance of stakeholder engagement in helping them address the sustainability issues related to their activities and discussed the initiatives taken to facilitate dialogue with the stakeholders. Stakeholder engagement is one of the indicators for environmental intention management apart from environmental education, environmental management systems, and environmental accounting, which are discussed by approximately 67%, 97% and 73% of the companies respectively.

Generally, every company disclosed their policy regarding environmental protection and responsible practices. Approximately 97% of the companies explicitly discussed their plans in addressing climate change and global warming; 93% discussed about conservation of habitat or ecosystem; and 87% discussed about biodiversity protection. However, only 17% companies revealed that they prefer to purchase eco-friendly products.

In terms of environmental vision, 87% of the companies expressed their commitment to good environmental performance and discussed the challenges that they face in fulfilling the commitment. The challenges include the difficulty in predicting the business impact of greenhouse gas (GHG) reduction measures because of the uncertainty in timing and outcomes of international, regional and national regulations (ExxonMobil, 2011). In addition, the O&G companies are also facing significant challenges, amongst others, in: (1) meeting regulation requirements to address issues related to air emissions, waste and new fuel specifications (Sasol, 2011), and (2) managing and reducing cumulative environmental risks and impacts related to resource and infrastructure investments (Eni, 2011).

Among environmental reporting measures, one of the least reported indicators is materials usage which is measured based on the implementation of product or process life cycle analysis, e.g. cradle to grave considerations of materials used in production. Only 17% companies reported that they have a formal life cycle analysis procedure in place, even though 60% of the companies studied indicated that they are concerned about the impact of production processes and product use on the environment and health. Environmental reporting indicators which are discussed most among the reports studied are GHG emissions (97%), carbon dioxide emission (73%), emissions to water (i.e. release of chemicals or waste to water bodies, 73%), pipeline monitoring and maintenance (67%), accidental spills (73%), wastewater recycling (83%), and water use (97%). In terms of energy, 83% companies discussed their energy usage; however, only 13% of the companies reported the use of renewable energy in their operations.

b. Social intent and reporting

Figure 3.3 shows companies' disclosure of their intent and performance related to social sustainability.

In terms of social accountability, 67% of the companies disclosed their health and safety, or social organizational structure, and appointed a third party to validate their sustainability report. For the management-related indicators, the most reported are employee training and emergency preparedness program. Specifically, 93% of the companies discussed the training provided for employee career development. Approximately 87% have emergency preparedness program in place to help employees and public community to prepare and cope with potential safety and health emergencies that could result from their operations.

Three indicators were used to measure companies' disclosure of their policy regarding social sustainability, namely social policy statement, code of business conduct/business ethics, and supplier screening/management. We find that all companies have formal social policy statement in the report. In addition, 97% of them expect all employees and contractors or suppliers to comply with their code of conduct. About 63% of the companies implement suppliers screening measures to determine the suppliers' ability to meet the companies' social or environmental policy and principles.

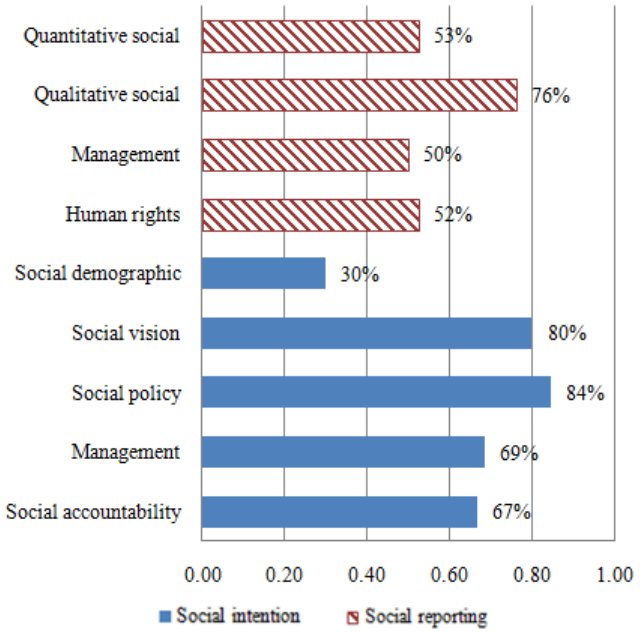

Figure 3.3 – Social intent and reporting disclosure

Human rights indicators which are reported most include elimination of discrimination related to employment and occupation (83%), rights of employees to join trade unions (83%), fair compensation (73%) and anti-corruption policy (73%). The least reported indicators are the companies' policy on degrading treatment and punishment to employees (27%) and sexual harassment (1%). In addition, only 37% of the companies conducted an employee satisfaction survey.

The qualitative social indicators are generally about companies social sustainability initiatives. Overall, all companies reported their community development and education, as well as occupational safety and health initiatives. The companies emphasized on the importance of occupational safety and health protection for their employees and contractors given the risk involved in O&G operations; about 77% discussed their efforts in providing employees with access to healthcare facilities. The quantitative social indicators, on the other hand, relate to companies' performance with regard to community investment, employee turnover as well as safety and health. Most reported indicators are social community investment (100%), recordable incident/accident rate (80%), fatalities (80%) and lost workdays (73%). It is interesting to discover that all companies disclosed their investment in community development (87% companies reported about environmental expenditures and investment). This indicates that companies would readily report information that could improve their social legitimacy and licence to operate. Generally, community development, education and investment dominated the discussions on social initiatives, especially among national O&G companies and the companies that operate in countries with strong government influence in the local O&G development.

c. Sustainability reporting score of individual company

The difference between companies' disclosure of their intention to sustainable practices and performance is shown in Figure 3.4.

We find that about 63% of the companies expressed higher intention for environmental management compared to social management. However, only four of these companies' reporting of environmental performance is more extensive than their social performance reporting. Generally, disclosure of social performance dominated the discussion in the

sustainability reports; 70% of the companies studied reported the social-related indicators more than the environmental indicators. This clearly shows the inconsistencies that exist in the sustainability reporting practices between environmental and social dimensions among the companies.

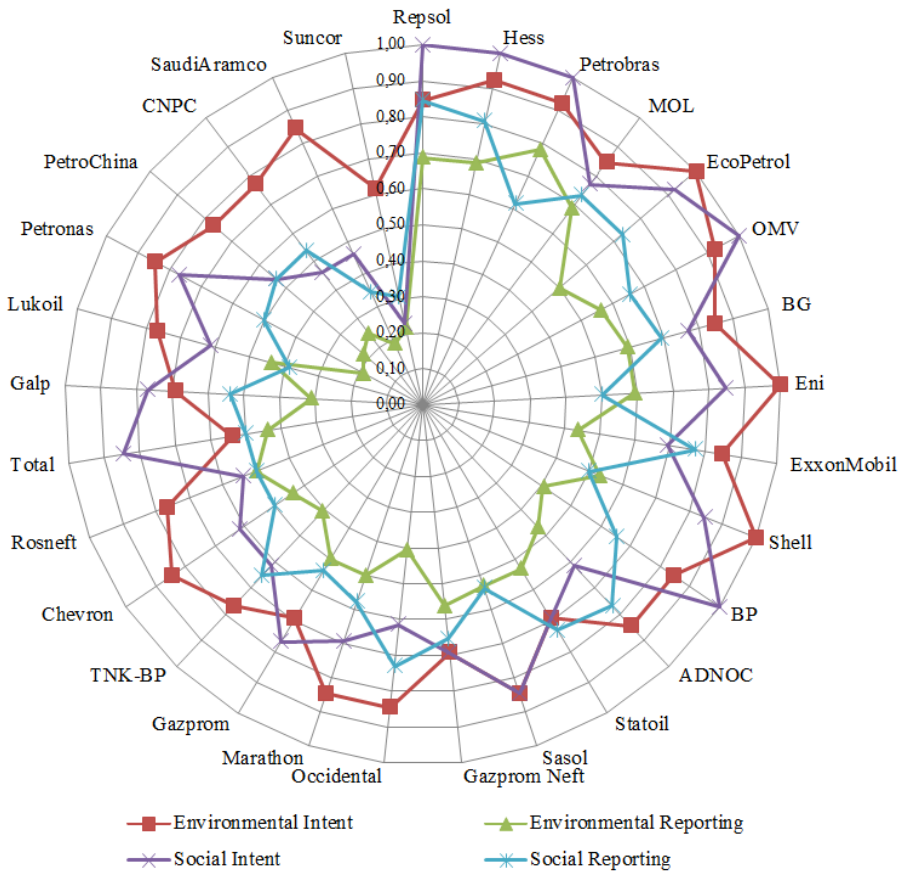

Figure 3.4 – Average score of intent and reporting disclosure in sustainability reports

An analysis of variance (ANOVA) was conducted to test the differences in the sustainability reporting practices between the three groups of companies in this study, in terms of environmental intent, environmental reporting, social intent and social reporting. Before the analysis, we checked for the normality and homogeneity of variance of our data. Normality test indicates that there are various degrees of normality in the data distribution, thus we assumed that the data are normally distributed. Levene's test shows that the variances in the three groups do not differ significantly (p>0.05). This fulfills the homogeneity of variances assumption required for ANOVA.

Through an ANOVA test, we discover that there is a significant difference in the environmental reporting practices between the groups; $F(4, 25)=4.182$, $p=0.01$. However, there are no significant differences in their disclosure of environmental intent, social intent, and social reporting at the $p<0.05$ level. A Tukey post-hoc test indicates that the environmental reporting score of companies that are listed in all three listings (Group A; mean=0.58, SD=0.12) is significantly different from the reporting of companies that are only listed in OGJ (Group C, mean=0.28, SD=0.16) at the $p<0.05$ level.

The analysis of individual company's total sustainability reporting score is as shown in Figure 3.5.

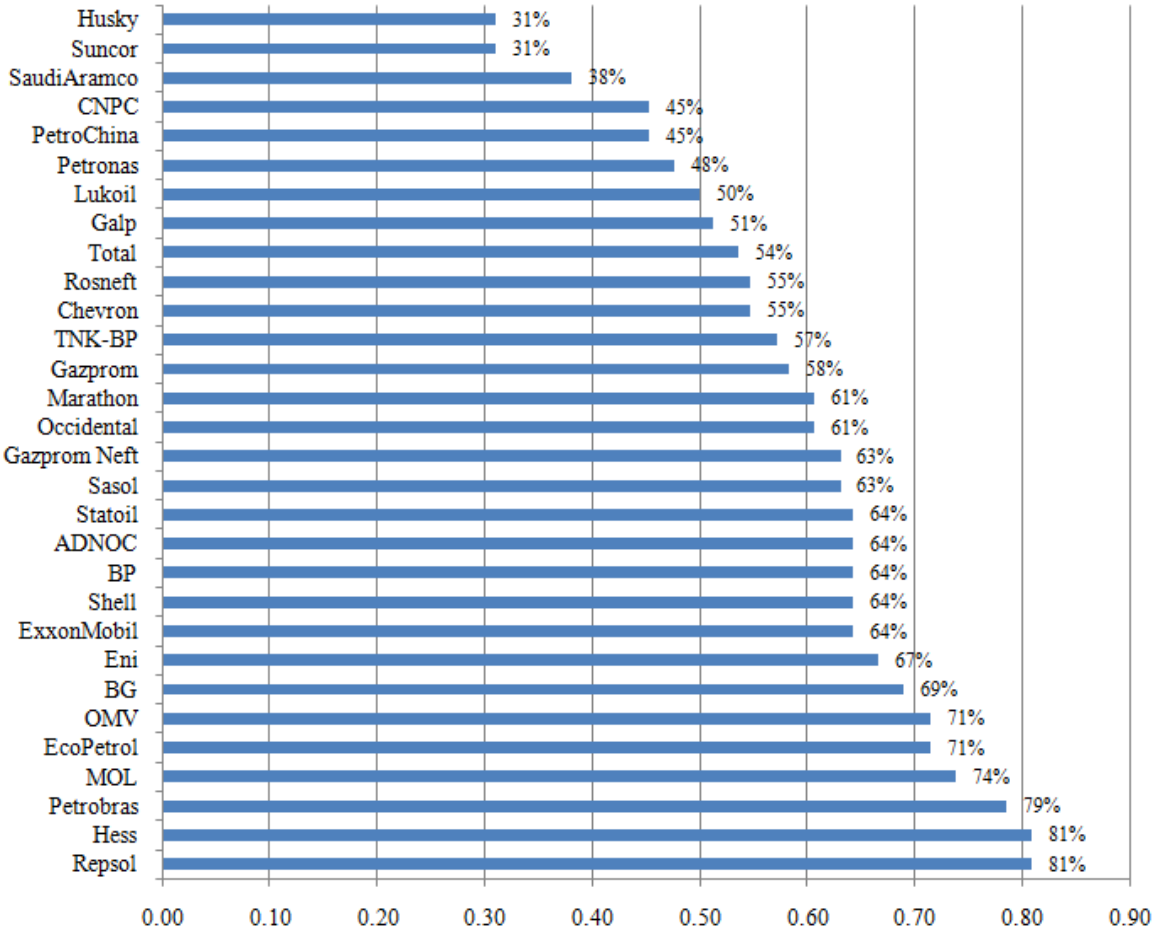

Figure 3.5 – Total score of sustainability disclosure

Overall, 80% companies disclosed more than 50% of the indicators used to measure the sustainability reports. It is important to note that some indicators may be more important than others, especially the indicators that are used to measure companies actual sustainability performance. For example, the reporting of hazardous waste released to the environment (reported by 42% companies) may have more impact on stakeholders than whether employees are free to participate in labour associations (reported by 92% companies). Further analyses on the differences between the reporting of intention and performance show that these companies reported, on average, 80% of intention-related indicators compared to only 57% of performance-related indicators. In addition, 54% companies expressed higher environmental intention, but 79% reported more on social performance. These findings could show the lack of objectivity and consistency in sustainability reporting practices among the O&G companies.

We find that Repsol, which is in Group A, has the highest overall score. This is not surprising, considering that the company was the sector leader in sustainability performance as announced by Dow Jones Sustainability Index 2010; DJSI does not rank the companies listed in its index, but announces the leader for each sector. All of the nine companies listed in the DJSI scored higher than 0.5 (reported at least 50% of the indicators). However, only six companies are in the top 10 among the companies studied.

3.4.2 Integration of sustainability in supply chain management practices

The term “supply chain” is mentioned explicitly by less than 50% of the companies in this study. Aspects related to supply chain management, however, are present throughout all of the

reports studied. Most of the companies that discussed their "supply chain" focused on the policies and management systems that are used to ensure the companies' sustainability strategies are supported by their suppliers and contractors. Through the content analysis, we seek to understand the integration of sustainable practices in the management of the following supply chain functional areas: supplier management, product stewardship and logistics management. The three functions are chosen because they are crucial in ensuring that the development and delivery of O&G products can be done in sustainable manner right from the planning stage, to acquisition of raw materials/services, distribution processes, and products' end-of-life consideration. Our findings for each function are as follows.

a. Supplier management strategy

Table 3.5 summarizes the supplier management strategy and its related challenges identified through the content analysis.

There are two indicators related to the supplier management function included in the Pacific Sustainability Index, namely *green purchasing* and *supplier screening*. Our analysis of the sustainability reports shows that only 17% companies expressed their preference for purchasing of eco-friendly products. In addition, 63% of the companies screen and select suppliers based on their ability to meet the companies' social and environmental policy requirements.

Table 3.5 – Supplier management practices in the O&G industry and challenges faced

Strategy/challenges	Descriptions
Supplier management strategy	• Selection and screening based on environmental and social/human rights criteria • Training for procurement staff to conduct supplier prequalification assessment • Supplier development programs in business & management skills, quality management systems, technical & leadership skills, sustainability-related issues, logistics chain etc. • Monitoring of suppliers • Due diligence investigation
Local content/supplier practices	• Issues to be considered in strategy implementation: a. Local business environment b. Local government economic priorities c. Local regulatory and legislative requirements d. Location of suppliers e. Competencies of suppliers f. Direct relationship with suppliers • Local content aspects: a. Materials b. Services c. Staff • Supplier development programs include: a. Management/administrative b. Finance c. Contract & tendering skills d. Health, safety and environment requirements e. Compliance with regulations & ethical business conduct f. Quality management systems
Issues in the implementation of local content/supplier strategy	• Scarcity of specialized local supplier • Local supplier competencies • Safety and product quality standards • Legal requirements differences between countries • Dependency on supplier conduct for sustainability performance • Compliance with local regulations & company's code of conduct & standards

Further analysis of the reports indicates that local content management strategy was given a considerable attention by the companies studied. Specifically, 57% of the companies discussed about local content management in their reports. Local content management generally relates to the inclusion of local businesses/suppliers, materials or workforce in an O&G development project (Ngoasong, 2014). The implementation of local content strategy is mainly attributed to local government's policies, which are often used as part of O&G project licensing agreement. Generally, the companies are positive about the policy because it helps them to fulfil their social responsibilities. The strategy helps in creating business and job opportunities as well building local competencies. These could consequently contribute towards economic development of local communities and businesses (Ecopetrol, 2011, Repsol, 2011, Shell, 2011). However, difficulties might arise in the implementation of the strategy due to the lack of local expertise especially for specialized products. In order to address the problem, companies have to hire international suppliers (Repsol, 2011), and require the suppliers to share a percentage of the contract given with local businesses (ADNOC, 2011).

There are also other factors that have to be considered in the implementation of local content strategy. This includes regulatory requirements, local business environment and infrastructure (ExxonMobil, 2011). In addition, the strategy requires close cooperation between companies and their suppliers. This is especially important for the O&G industry because of its high requirements for safety and product quality standards. In such instances where local competencies are inadequate, companies have to train local workforce and businesses in aspects such as safety, product quality as well as business and technical skills (ExxonMobil, 2011), which could increase the companies' operating costs.

b. Product stewardship strategy

The product stewardship strategies employed by the companies to address product life-cycle issues are summarized in Table 3.6.

Approximately 60% of the companies studied discussed their concerns regarding the impact of production activities and product use on the environment and health. Shell (2011) suggests that among the strategies that can be used to address the sustainability issues include using less energy in production processes, reducing the resources used in product packaging and finding innovative uses for by-products. However, we find only five companies (17%) disclosed that they conduct life-cycle analysis to manage product impacts right from planning stages to its end-of-life considerations.

We find that regulatory requirements drive companies to pay greater attention on the health, safety and environmental impacts of its activities and products. For instance, Shell engage its suppliers to ensure that the materials purchased meet European Union's requirement related to the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) (Shell, 2011); ExxonMobil assesses its products' compliance with regulatory requirements both where they are produced and in their intended market (ExxonMobil, 2011).

In general, we found that 33% of the companies have a clear product stewardship policy and considered the approaches that can be used to measure its implementation. However, the reporting of the performance related measures in the reports is largely absent. Most companies described their strategy, but failed to provide the data that can be used to assess their performance. Companies like Repsol, OMV and ExxonMobil, for example, provide safety data sheets that can be used by suppliers, customers and other stakeholders to assess the health risks associated with the use and handling of O&G products (Repsol, 2011, OMV, 2011, ExxonMobil, 2011). However, little is known of how the information provided through

the data sheets improves product handling processes by contractors, or if there is a reduction in materials usage for product packaging.

Table 3.6 – Product stewardship strategy used by O&G companies

Strategy	Descriptions
Evaluate, monitor and issue information about the health & environmental risks of products.	• Report GHG emissions associated with the production and end use of fuel, natural gas and other products • Analyze danger posed by raw materials and end products • Produce safety data sheets to communicate risks throughout supply chain • Product appraisal for compliance with local and global regulations • Develop own standards where laws & regulations are considered inadequate or does not exist • Seek assurance from suppliers that all procured materials meet regulation requirements (e.g. REACH)
Provide information to those who transport, use and dispose products.	• Appropriate uses • Potential health and environmental effects • Personal protection and exposure controls • First aid measures • Disposal considerations
Life-cycle or integrated approach to product safety & health	• Consider the movement of products throughout their life-cycle and the variety of management issues which might occur from the extraction of raw materials to end of life; • Management of product quality from production through storage and transport to sale. • Redesign bottles and cartons to fit more cases per pallet and improve transportation efficiency
Management systems/ standards	• Use of product stewardship information management system (PSIMS): a. Applies common global processes and a single global computer system to capture and communicate information on the safe handling, transport, use and disposal of products; b. Incorporates automated assessments to consistently appraise product characteristics and uses for compliance with existing global laws and regulations; c. Provide responsible standards to specify precautions where laws and regulations do not exist or are considered inadequate.

c. Logistics management strategy

In terms of logistics management, 73% of the O&G companies discussed their strategy in minimizing or eliminating negative impacts of logistical activities on the environment, safety and health. However, only one company (i.e. Ecopetrol) explicitly disclosed that it has a formal reverse logistics program. The strategy implemented by the company includes adding new commercial vehicles, updating the existing vehicles, and developing instructions for handling of materials and assets which are not required for operations (Ecopetrol, 2011). The strategy is intended to ensure that the company can generate economic benefits from savings or sales of waste and, surplus or obsolete assets. In addition, the strategy could also ensure that environmental risks from inadequate completion of the life cycle of products used in operations can be managed and prevented appropriately.

Transportation safety is a major concern among the O&G companies studied, where 66% of them discussed about the issue. Further analysis of the reports indicates that only a few companies clearly outlined their strategy in ensuring safe transportation activities; mostly in terms of vehicle audits and inspection (10%), vehicle monitoring (7%), journey management plan or routes planning (13%) and commuter programs for employees (7%). About 67% of the companies reported that they conduct pipeline monitoring and maintenance.

Among the challenges that the companies faced in their logistics activities is the increase in extreme weather events that could affect transportation infrastructure, such as road, maritime, inland waterway and pipelines (OMV, 2011, Petrobras, 2011). As sources of O&G supply are often located far from consumer markets, this increases the risks involved in supply delivery. In order to address this issue, the companies employ several strategies that focus on: (1) increasing collaboration between commercial logistics department and customer care services (Repsol, 2011); (2) developing competitive logistics networks and exploiting synergies through the use of multi-modal transportation (Ecopetrol, 2011, MOL, 2011); and substituting road transportation for pipelines and waterways (Petrobras, 2011). These strategies are meant to improve the frequency of routes and supplies, reduce the environmental impact of transportation activities, and to minimize costs, which could also lead to increased customer satisfaction along more conventional business lines.

Table 3.7 summarizes our findings regarding the logistics management strategy discussed in companies' sustainability reports.

Table 3.7 – Logistics management strategy used by O&G companies

Strategy	Descriptions
Collaboration/ partnership	• Establish long-term relationships with partners in transportation area to create synergies that can strengthen business model • Increase collaboration between commercial logistics departments and customer care services to optimize and improve the frequency of routes and supplies • Work with service companies to better manage truck and heavy equipment transportation • Participation in national task team on road incident management systems
Green logistics	• Actively selects environmentally-conscious logistic service provider • Shipping and inland waterway: a. Improve planning and scheduling of vessels to reduce greenhouse gas emissions b. Use proactive engine maintenance approach c. Ship vetting system to protect the environment and preserve marine life d. Apply rigorous and systematic screening process to prevent spills during transportation activities e. Uses returnable containers for efficient sea freight loading • Workers commuting program: a. Provide shuttle bus services to transport staff to and from their place of work b. Encourage car sharing c. Minimize business-related travel through the use of video- and teleconferencing d. Discourage employee commuting by private cars by limiting the number of passes to industrial areas • Convert light petrol driven vehicles to use natural gas • Reduce the use of road tankers for the transportation of products from refineries by using inter refinery pipeline
Transport safety	• Installation of monitoring devices in vehicles: a. Make vehicle tracking systems obligatory b. Introduce a system to control and improve the use of on-board vehicle monitoring by contractor organizations • Safety training for drivers: a. Intensify supervision of the defensive driving training program b. Safety training module to increase awareness of common road hazards, high risk zones & expected driving behaviors • Use accident analysis and feedback that focus on the interfaces between different transport modes and logistics providers; • Safety guidelines on maritime and inland waterway terminal – e.g. communication with ships, technical operational precautions and the use of brief call reports • Safety self-assessment checklist for terminal managers • Preferential selection of contractors who actively renew their automobile and special purpose vehicles. • Continually verify that vehicles used comply with the most demanding safety regulations

3.5 Discussion

The results of the content analysis indicate that companies tend to disclose their intention towards sustainable practices more than the actual performance. On top of it, companies, in general, expressed more commitment towards environmental sustainability, when their reporting of the social performance is actually higher than the environmental performance. Therefore, inconsistencies are evident in the sustainability reporting practices among the companies.

Generally, 63% companies that have higher environmental sustainability intent reported more extensively on their social performance than the environmental performance. The lack of environmental performance reporting is consistent with the studies conducted by Clarkson et al. (2008). They also found that companies with superior environmental performance are the ones that are more likely to report performance aspects, especially those related to voluntary disclosure.

Environmental reporting requires collection of measurable data such as emissions, material consumption, and waste production and management. Altogether, there are 32 quantitative environmental indicators and 13 qualitative indicators in the questionnaire used in this study. Social reporting indicators, on the other hand, are mostly based on qualitative measurements such as company's policy towards human rights practices, code of conduct, and community development. There are eight quantitative indicators, against 31 qualitative indicators, that measure social reporting aspects such as turnover rate, safety performance and community investment. Generally, about 80% of the social indicators are qualitative in nature. Therefore, sustainability reporting tends to become rather narrative or descriptive when social performance is reported more than environmental performance. The same can be said when companies focus more on discussing their intention or commitment to sustainable practices with little to no reporting of measurable performance outcome in the report.

We also find that the environmental reporting of triple-listed companies (Group A) is significantly different (better) than the reporting of companies that are only listed in OGJ (Group C). The companies in both groups were among the world's largest O&G companies based on oil equivalent reserves. However, Group A consists of companies which were also listed among the top 40 in the Platts Top 250 Global Energy Company (companies are ranked based on financial standings). Therefore, it could be assumed that better financial capability could help a company to have a more comprehensive environmental reporting. This could be attributed to their ability to invest in, for instance, more sophisticated environmental management measures.

However, caution should be taken when making such generalization because one of the companies in Group C, Abu Dhabi National Oil Company (ADNOC), is the sixth largest O&G company in the world and, therefore, can also be assumed to have the financial capability to invest in such measures. The reason why ADNOC is not listed in Platts as one of the company with good financial standing is beyond the scope of this discussion. Nevertheless, a factor that could be considered is the type of company ownership; i.e. international oil companies (IOCs) versus national oil companies (NOCs). Wolf (2009) found that the financial performance and efficiency of IOCs are better than NOCs. ADNOC is an NOC, but so are most companies in Group A (i.e. Petrobras, EcoPetrol, Eni and Statoil) and all companies in Group C. The fact that the environmental reporting of these two groups of companies differs significantly, therefore, cannot be attributed to ownership factor.

The analysis of individual company sustainability report scores also revealed that while a good financial position could result in better sustainability disclosure, it is not a sufficient condition. We found that the total sustainability reporting score of ADNOC is higher than 59% of companies listed in Platts (i.e. 14 companies, 12 of which are in the top 50 of the

ranking). Thus, it could be concluded that a good financial position is necessary but not a sufficient factor for a comprehensive disclosure of sustainability initiatives and performance. Perhaps factors such as companies management orientation towards sustainability and organizational culture can also affect sustainability reporting practices among the companies (Walker and Jones, 2012, Hussain, 2011, Pagell and Wu, 2009). These organizational factors could be the differentiating factor that separates those companies that report more extensively than the rest.

In terms of the integration of sustainability in SCM practices, it is unclear how that aspect is being extended beyond the practices of the companies themselves. The strategy that the companies adopt to improve supply chain sustainability is mainly concentrated on ensuring that suppliers or service providers are able to meet the requirements for socially and environmentally responsible operations through services or materials they provide. However, measuring the effectiveness and the impact of the strategy on the supply chain's overall performance is quite difficult. Companies must also consider the implementation issue related to the differences in suppliers' capabilities and resources in complying with the requirements. Careful considerations must be given to avoid discrimination against smaller companies.

We found that the companies employ supplier management and development strategy that seek to equip their suppliers with managerial and technical skills that could contribute towards improving overall supply chain sustainability. Seuring and Müller (2008) emphasize that supplier development and integration should be the focus of proactive companies since reactive approach to supplier's non-conformance could be more costly to supply chain's sustainability. The proactive approach could include supplier monitoring and training. Collaboration among supply chain partners is also crucial to the overall performance of the chain. It could help in identifying supply chain solutions that can improve its capabilities and competitiveness (Gold et al., 2010), such as in environmental technology development, environmental audits, training and improvement of logistics activities (Kovács, 2008, Tesfay, 2014, Yusuf et al., 2014).

The last finding from this study is related to the reporting of supply chain aspects. There is a lack of indicators that a company can use to assess its supply chain performance. We used the PSI index that was developed based on roughly a decade of research on sustainability reporting practices. Given that most companies use the sustainability reporting guidelines by the GRI and other industry-specific bodies, for example, the International Petroleum Industry Environmental Conservation Association (IPIECA), then this in itself is an indication that the coverage of supply chain indicators is lacking. SSCM literature can help address this issue as various studies have been conducted to identify the indicators that can be used to measure supply chain performance, see for example Zhu et al. (2008), Bai and Sarkis (2014) and Beske and Seuring (2014).

Janus and Murphy (2013) argued that the O&G industry will be burdened by the works required to comply with the new sustainability reporting guideline by the GRI, and that this would outweigh its foreseeable real benefit. Since the publication of sustainability report is done by companies on a voluntary basis, the lack of relevant, manageable and useful guidance (Janus and Murphy, 2013), might hinder a meaningful progress in reporting practices of these companies.

Nevertheless, there need to be greater accountability among companies regarding the impact of their activities on the environment and society wellbeing. The increase in the number of O&G companies that publish sustainability reports indicates the strategic importance of public disclosure of sustainability performance to their corporate legitimacy. Sustainability reporting guidelines, therefore, should be able to assist companies in identifying practically relevant criteria that can help assess and improve the sustainability of their activities. The companies, on the other hand, should not treat the voluntary nature of

sustainability reporting as an excuse to selectively communicate or disclose aspects that are able to paint a favourable picture of their commitment to and performance in sustainable practices. This content analysis provides a good starting ground in understanding how sustainability issues are being addressed by companies in the O&G industry. However, more studies are needed to validate our findings further.

3.6 Conclusion

Based on the content analysis of sustainability reports of companies in the O&G industry, we found that the companies generally have clear sustainability policy related to their commitments and plans towards environmentally and socially responsible practices. However, what matters most is to translate those commitments and policies into measurable indicators that can help the companies to: (1) assess their progress in sustainable practices, (2) identify opportunities for improvement, and (3) identify areas of priorities that could lead to more effective implementation of sustainability strategy. In these areas, their reporting performance seems notably weaker.

The current sustainability reporting practices are concentrated on communication of the companies' intention towards sustainable practices. The reporting of measurable performance can be improved. There is also inconsistency in the sustainability reporting practices with regard to their disclosure of intention and performance. Even though the companies expressed higher environmental intention compared to social intention, the reporting of social performance is higher than environmental performance. We also found a lack of guidelines in the reporting of supply chain-related performance. It implies that concerted efforts are needed from the companies in the O&G industry and its associated institutional bodies to clearly identify the indicators that can be used to measure supply chain sustainability.

There are several limitations of this study that could be addressed in future research. First, we only consider whether topics are discussed or not in a report. The extent to which a topic is meaningfully discussed by a company was not measured. There may be instances in which a company's discussion is more elaborate than others. In addition, the voluntary nature of sustainability reporting could influence the quality of their disclosure. Therefore, future research could look into understanding the discourse within sustainability reports that can provide good measures of the extensiveness of reporting and materiality of information disclosed. Second, this study uses cross-sectional data, which cannot serve the identification of patterns in reporting practices over time. The evolution of reporting practices is an interesting topic that could help us understand progress, or the lack thereof, that companies make towards achieving sustainable practices. Researchers could also compare environmental and social performance of companies over time using sustainability ratings developed by, for example, Trucost and MSCI ESG.

The third limitation of this study is that we only focus on O&G companies that publish a sustainability report. A study that compares sustainability practices of reporters and non-reporters may result in valuable findings regarding sustainability strategies and performance of these groups. It would also allow us to understand the motivation behind disclosure (or non-disclosure) of sustainable practices. For this purpose, researchers could employ a case study method to obtain data through, for example, interviews with managers and employees, as well as analyses of secondary data, such as company policy documents and news reports.

This chapter focuses on O&G companies' disclosure of their intention (commitment) and performance related to sustainable practices. In addition, it discusses the strategies that they used to integrate sustainability in their supply chain management practices. In the next chapter

we discuss the factors within the O&G industry's external business environment that could influence companies' adoption of sustainable supply chain management practices.

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4. External Factors of Supply Chain Sustainability

This chapter is based on a paper currently under review as: Wan Ahmad, W.N.K., Rezaei, J., Sadaghiani, S. and Tavasszy, L.A. "An evaluation of the external forces affecting the sustainability of oil and gas supply chain using Best Worst Method".

4.1 Introduction

Every company operates in a context that is unique to its business, product and/or industrial characteristics. Understanding this context is important since it allows formulation of SSCM strategies that consider the external factors that could affect the company's supply chain performance. Current research on SSCM of O&G still falls short in understanding such factors. This chapter aims to address this gap by identifying the important external factors that could drive or hinder the adoption of SSCM practices in the O&G industry.

Here, we focus on the six external factors discussed in Chapter 2, namely political stability, economic stability, stakeholder pressure, competition, energy transition and regulations. Managers often have to prioritize companies' resources in tackling the pressure from the external factors. Therefore, we consider the problem of evaluating the importance of these factors in influencing the adoption and achievement of sustainable supply chain practices as a multi-criteria decision-making (MCDM) problem. To solve this problem, this study uses a very recent MCDM method which is the Best Worst Method (BWM). We conducted a survey among academic experts in the field of SSCM and O&G to collect the necessary data. Through our analysis, we aim to answer the following question:

> *What are the most important external factors that can influence the O&G industry's adoption of SSCM practices?*

We have discussed the external factors quite extensively in Chapter 2; therefore, they are not included in this chapter. The rest of this chapter is organized as follows. Section 4.2 describes the methodology used in this study. Next in section 4.3, we discuss the results of our

analysis. Finally, Section 4.4 concludes this chapter and offers several implications for practice as well as opportunities for future research.

4.2 Methodology

In this section, we will first explain the BWM method that is used to assess the importance of the external factors and then describe our survey questionnaire. This will allow us to explain the structure of the questionnaire and how respondents can answer it more clearly.

4.2.1 Best Worst Method

Decision making in SSCM implementation is a complex and difficult process because managers need to consider and rationalize various factors (i.e. decision criteria) simultaneously. The use of MCDM can help reduce the difficulty as it is able to analyze complex problems such as those that involve high uncertainty, conflicting objectives, multiple perspectives, and various types of data (Wang et al., 2009).

There are several MCDM methods that can be used to weight multiple decision criteria and obtain the solution to a problem such as Swing, simple multiattribute rating technique (SMART), fuzzy preference programming, analytic hierarchy process (AHP), and analytic network process (ANP). These methods use pairwise comparisons to evaluate a set of decision alternatives based on decision makers' or experts' judgment. Several factors can influence the consistency of the comparisons such as complicated questionnaire, lack of knowledge and respondent fatigue. Rezaei (2015) argues that this is a methodological problem that can be solved with a more structured comparison approach, and proposed a new MCDM method for this purpose called Best Worst Method (BWM).

Generally, BWM derives weights for a set of decision criteria using pairwise comparison of the best (i.e. most important, most desirable) and the worst (i.e. least important, least desirable) criteria with the other criteria in the decision criteria set. According to Rezaei (2015), BWM is a robust MCDM method due to several salient features. First, it is a vector-based method where fewer comparisons are needed compared to full pairwise comparisons matrix used in, for example, AHP. This is an important advantage because it can reduce the complexity and the time required for decision makers or experts to evaluate the required criteria. It can also be more convenient for research that requires participation from less accessible respondents. Second, BWM produces highly consistent comparisons that lead to results with a high level of reliability. Third, this method can be used independently to derive weights, or in combination with other MCDM methods. Finally, BWM is also easier to be applied because it only uses integers. Some examples of the application of this method are in supplier segmentation (Rezaei et al., 2015), in freight bundling configuration (Rezaei et al., 2016) and in identification of the most important enablers of technological innovation (Gupta and Barua, 2016).

Due to the advantages offered by BWM, as described above, we chose to employ this method to evaluate the importance of the external factors in influencing the adoption of SSCM practices in the O&G industry. There are five steps used in BWM to derive the weights of decision criteria (Rezaei, 2015). These are as follows:

Step 1: Determine a set of decision criteria $\{c_1, c_2, \dots c_n\}$

Based on the literature review, six external factors were identified as the main criteria of this study namely political stability (POL), economic stability (ECO), stakeholder pressure (STH), competition (COM), energy transition (ETR) and regulations (REG). Each of the

main criteria constitutes three to seven sub-criteria that together determine its importance in SSCM implementation.

Step 2: Determine the best (e.g. the most important) and the worst (e.g. the least important) criteria from the main set of criteria $\{c_1, c_2, \dots c_n\}$
A (or a group of) decision-maker(s), i.e. in this study, experts in the fields of SSCM and O&G, determine the most and the least important factors among the set of the external factors.

Step 3: Conduct pairwise comparison between the best criterion and the other criteria.
The respondent must assign a number from 1 to 9 to indicate the importance of the selected most important external factor over the other external factors in the set.[1] This will result in Best-to-Others vector, which is:

$$A_B = (a_{B1},\ a_{B2}, \dots,\ a_{Bn}),$$

where a_{Bj} represents the importance of the most important criterion *B* over criterion *j*, and $a_{BB} = 1$.

Step 4: Conduct pairwise comparison between the other criteria and the worst criterion.
Similarly, the respondent is required to indicate the importance of all the external factors in the set over the least important factor using a number between 1 to 9. This will result in Others-to-Worst vector, which is:

$$A_W = (a_{1W}, a_{2W}, \dots, a_{nW})^T,$$

where a_{jW} indicates the importance of criterion *j* over the worst criterion *W*, and $a_{WW} = 1$.

Step 5: Find the optimal weights $(w_1^*, w_2^*, \dots, w_n^*)$
The optimal weight for the criteria is where $w_B/w_j = a_{Bj}$ and $w_j/w_W = a_{jW}$ for each pair of w_B/w_j and w_j/w_W, respectively. The maximum absolute differences $\left|\frac{w_B}{w_j} - a_{Bj}\right|$ and $\left|\frac{w_j}{w_W} - a_{jW}\right|$ for all *j* must be minimized in order to satisfy this condition. Taking into consideration the non-negativity and sum condition for the weights, this will result in the following model:

$$\min \max_j \left\{ \left|\frac{w_B}{w_j} - a_{Bj}\right|, \left|\frac{w_j}{w_W} - a_{jW}\right| \right\}$$

s.t.

$$\sum_j w_j = 1$$

$$w_j \geq 0, \text{ for all } j \qquad (1)$$

[1] Definition of 1 to 9 measurement scales:

1 = equal importance	7 = Very strongly more important
3 = Moderately more important	9 = Extremely more important
5 = Strongly more important	2, 4, 6, 8 = Intermediate values

Model (1) can be transferred into:

$$\min \xi$$

s.t.

$$\left|\frac{w_B}{w_j} - a_{Bj}\right| \leq \xi, \text{ for all } j$$
$$\left|\frac{w_j}{w_W} - a_{jW}\right| \leq \xi, \text{ for all } j$$
$$\sum_j w_j = 1$$
$$w_j \geq 0, \text{ for all } j \quad (2)$$

Solving model (2) produces the optimal weights $(w_1^*, w_2^*, \dots, w_n^*)$ and ξ^*. There would be more than one optimal solution for not-fully consistent problems with more than three criteria (Rezaei, 2016). Therefore, the solutions of model (2) must be used to calculate the lower and upper bounds of the weight of criterion *j* using the following models:

$$\min w_j$$

s.t.

$$\left|\frac{w_B}{w_j} - a_{Bj}\right| \leq \xi^*, \text{ for all } j$$
$$\left|\frac{w_j}{w_W} - a_{jW}\right| \leq \xi^*, \text{ for all } j$$
$$\sum_j w_j = 1$$
$$w_j \geq 0, \text{ for all } j \quad (3)$$

$$\max w_j$$

s.t.

$$\left|\frac{w_B}{w_j} - a_{Bj}\right| \leq \xi, \text{ for all } j$$
$$\left|\frac{w_j}{w_W} - a_{jW}\right| \leq \xi, \text{ for all } j$$
$$\sum_j w_j = 1$$
$$w_j \geq 0, \text{ for all } j \quad (4)$$

The final weight of the criteria can be calculated using the following equation.

$$w_j^* = (\min w_j + \max w_j)/2 \quad (5)$$

A fully consistent comparison is achieved when $a_{Bj} \times a_{jW} = a_{BW}$ for all *j*. Rezaei (2015) proposes consistency ratio, which is calculated using ξ^*, as an indication of the extent of a comparison's consistency. The comparison becomes less reliable for bigger values of ξ^*. A consistency index that uses the maximum possible ξ (max ξ) for different values of $a_{BW} \in \{1, 2, \dots, 9\}$, as shown in Table 4.1, is proposed by Rezaei (2015) to aid the analysis.

Table 4.1 – Consistency index (CI) Table (Rezaei, 2015)

a_{BW}	1	2	3	4	5	6	7	8	9
CI (max ξ)	0.00	0.44	1.00	1.63	2.30	3.00	3.73	4.47	5.23

Using the index in Table 4.1, the *consistency ratio* $\in [0, 1]$ can be calculated as:

$$Consistency\ Ratio = \frac{\xi^*}{Consistency\ Index} \tag{6}$$

In the following section, we describe the data collection approach used in this study.

4.2.2 Data collection

We developed a set of questionnaire to identify the importance of the external factors to SSCM practices in the O&G industry. The questionnaire uses a scale of 1 to 9 to determine the importance ratio. The questionnaire contains 21 questions. For illustration purposes, here is an example of the questionnaire structure and how it can be answered – this is based on Step 2 to Step 4 in BWM's five steps approach.

In this example, respondents are asked to evaluate the importance of the external factors. The respondents must indicate the most and the least important factors in the first question (Step 2). For instance, economic stability is chosen as the most important factor and political stability as the least important factor.

1. Several "external factors" could affect supply chain sustainability as listed below. In your opinion, what is the **MOST** and the **LEAST** important factor?

Main criteria	Most important	Least important
Economic stability	x	
Political stability		x
Competition		
Regulation		
Energy transition		
Stakeholder pressure		

After the most important factor has been determined, respondents need to indicate their preference or their opinion regarding the importance of that factor over the other external factors (Step 3).

2. You have selected *XX (in this example, economic stability)* as the most important factor.

   Please determine your preference ratio of this factor over the other factors by using 1 to 9 measurement scale (1 shows equal importance and 9 means the economic force is extremely more important. Please check below for detailed explanation of 1 to 9 scales)

Criteria / Most important	Economic stability	Political stability	Competition	Regulation	Energy transition	Stakeholder pressure
Economic stability	1	7	3	2	5	2

Then, the respondents must indicate the importance of other external factors over the least important factor (Step 4).

3. You have selected XX *(in this example, political stability)* force as the least important factor. Please determine your preference ratio of the other factor over the least important factor by using 1 to 9 measurement scale.

Criteria / Least important	Political stability
Economic stability	7
Political stability	1
Competition	5
Regulation	6
Energy transition	2
Stakeholder pressure	4

Similarly, respondents are then required to evaluate the importance of the criteria used to measure the six external factors examined in this study, as illustrated in the example – 3 questions for each external factor. Please see Appendix II for the full questionnaire. The questionnaire is similar to the one used in the survey among companies in the O&G industry.

Data for this study were gathered through an online survey among academic experts in the supply chain and O&G field. The target respondents were identified through our network of top universities in these fields that are located in the United States and Europe. The experts were chosen for their general insight about O&G and supply chain sustainability issues. We assumed that the experts have the ability to take various factors within the industry's operating context into account in their evaluation of the external factors.

Survey invitations were sent to 500 experts followed by four reminders in a period of two months. We received 74 responses where 48 are completed, which make the effective response rate to be approximately 10%. Table 4.2 shows the field of expertise of our respondents. The results indicate that there is a satisfactory representation of expert areas among the respondents from petroleum to management and sustainability field.

Table 4.2 – Respondents' field of expertise

Field of expertise	Number of respondent(s)*
Petroleum/ (petro)chemical engineering	18
Petroleum	13
Sustainable supply chain management/ logistics	12
Energy technologies/ alternative energy	3
Sustainability/ environmental management	5
Economics	2
Futures studies, technology assessment, systems innovation	1
O&G decision making	1
Operations research	1

* Some respondents provide multiple areas of expertise

Table 4.3 shows the respondents location. The majority of the experts are from American universities, which is approximately 63%.

Table 4.3 – The location of respondents

Country	Number of respondent(s)
USA	30
Netherlands	9
UK	3
Other European countries	5
Missing	1
Total	48

4.3 Results and discussion

The analysis of the survey outputs allowed us to compute weights of all the criteria and its underlying sub-criteria. In addition, the empirical material, together with the literature on SSCM and the O&G industry, provide the basis for a detailed interpretation of our findings, at the level of the main criteria and the underlying sub-criteria.

Table 4.4 shows the results of the analysis for the main external factors (we calculate the average of the weights considering all the respondents). The consistency ratio (CR) of the comparison is 0.20, which indicates a very consistent comparison; a comparison is more consistent the closer CR value is to 0 (Rezaei, 2015). Generally, the comparisons of all sub-criteria of the main forces are also highly consistent where the highest CR is 0.22.

Table 4.4 – The importance of external factors to SSCM of O&G

Sub-criteria	Weight	Rank	ξ	CR
Political stability (POL)	0.15	3	0.66	0.20
Economic stability (ECO)	0.34	1		
Stakeholder pressure (STH)	0.13	4		
Competition (COM)	0.17	2		
Energy transition (ETR)	0.10	6		
Regulations (REG)	0.12	5		

Our findings indicate that the respondents perceive economic stability (ECO) as the most important factor that could affect SSCM of O&G. Economic stability has a strong tie with oil prices, which can determine the profitability of O&G development projects. O&G production costs have increased in recent years due to factors such as geopolitical stability, tight market conditions, development of new frontiers, and shortages in the service and equipment sectors (Aguilera, 2014, Mitchell and Mitchell, 2014, Nuhu et al., 2014). Environmental and social initiatives are also costly endeavours (Carter and Rogers, 2008), but inaction could damage companies' reputation and affect their social license to operate (Matos and Silvestre, 2013). Stable economic conditions, therefore, enable companies to focus on exploring new business opportunities as well as improving the sustainability of their supply chain.

It is rather interesting to find 'regulations' (REG) as the second least important factor that could affect SSCM practices in the O&G industry. Existing studies indicate that regulatory factor is among the most important pressure for sustainable practices in the supply chain (Zhu et al., 2005, Seuring and Müller, 2008). The factor can lead to a higher level of green supply chain management practices among chemical/petroleum companies (Zhu et al., 2007).

The reason for this finding could be because the experts think that a more competitive market and greater stakeholder pressure would force companies to improve supply chain sustainability, even during the absence of regulatory pressure. This could be driven by the needs to improve a company's legitimacy as responsible corporate citizen and to gain competitive advantage in the market (Carter and Rogers, 2008). Stable economic and political conditions could facilitate such improvement, as it would provide a more conducive environment for companies to focus their resources on dealing with operational and strategic issues related to the management of supply chains. Wagner and Armstrong (2010) point out that leading companies in the O&G industry conduct environmental, social and health impact assessment (ESHIA) even when it is not required by law or financing institutions to minimize the risk of non-compliance. This could indicate that regulatory pressure is a sufficient, but not a necessary factor, for companies to adopt a more sustainable supply chain practices.

Energy transition is the least important factor among the external forces. The transition to low carbon energy systems that favours alternative energy based on renewable sources is driven by the needs to address climate change issues associated with the exploitation of fossil

fuels. Furthermore, the uncertainty regarding future availability of these finite resources has raised energy security concerns, and has induced a search for alternatives. However, current infrastructures heavily rely upon fossil fuel-based energy systems. This has created technological lock-ins, and will require tremendous efforts and cost to change. In addition, the progress of alternative energy development and its rate of diffusion are still slow (Verbruggen et al., 2010). These factors could have created a comfortable position for the companies in the O&G industry, compounded by the prediction that the O&G would remain the major source of energy for decades to come (Verbruggen et al., 2010, BP, 2014, Fouquet, 2010). Therefore, the respondents may have perceived that there is little sense of urgency for the companies to improve the sustainability of their supply chain practices to prepare for the transition.

Generally, the differences in the relative importance between the external factors are not large, apart from ECO. This, to some extent, implies that managers must carefully consider the factors simultaneously, while considering the company's resources and capabilities. This is to ensure that it can develop a strategy that can address the external challenges in supply chain effectively. This is when MCDM can be a helpful tool in decision making processes, as it could help managers to weight several issues against each other simultaneously. It would enable them to identify how changes in their priorities, choices or, in this case, the level of importance given to the external factors could affect decision making processes, eventually the resulting strategy and even its outcome.

We continue the discussion of how the factors could affect SSCM practices in the O&G industry based on the importance given to their sub-criteria by the experts involved in the study. The discussion will be in the order of the importance of the external forces, from the most important to the least important.

First: economic stability

As mentioned earlier, ECO is markedly the most important external factor and there is a consensus among the respondents of its importance compared to the others. We measured economic stability based on company's ability to invest on business development and sustainability programs, as shown in Table 4.5.

Table 4.5 – The importance of investment for supply chain sustainability

Sub-criteria	Weight	Rank	ξ	CR
Capital investment program (ECO1)	0.52	1	0.31	0.14
Investment in environmental protection program (ECO2)	0.35	2		
Investment in social assistance program (ECO3)	0.13	3		

The analysis reveals that capital investment (ECO1) is the most important investment for companies. Investment, for example, to improve existing infrastructure or for research and development, could help in business expansion and value creation. This will help companies to maintain themselves and remain in business, which is arguably the main priority of every profit-driven company, before it can focus on improving supply chain sustainability effectively. Carter and Rogers (2008) suggest that it would be irresponsible for a company to embark on sustainability initiatives at the expense of its economic performance since many, such as employees and business partners, are dependent on its survival.

Nuhu et al. (2014) discover that the exploration investment behaviour of the Organization of the Petroleum Exporting Countries (OPEC) is dominated by the economic factors that favour high oil prices. The higher oil prices could also stimulate investment in new production, alternative fuels, and energy efficiency (Mitchell and Mitchell, 2014). However, the global economic slowdown has caused a rapid decline of oil prices since June 2014 where it currently hovers at about $30/barrel after a relatively stable four-year period of about

$105/barrel. This represents a significant loss of revenues to the O&G companies that can affect their investments.

The 2008 economic crisis, for example, resulted in an estimated 14% cut of total investment by 50 leading O&G companies (IEA, 2009). Recently, ExxonMobil and Total have announced 10-12% reduction of their planned spending for 2015 due to the low oil prices. Similarly, Shell is cutting more than $15 billion of its spending for 2015 to 2017. The company will be focusing on strategic projects that could create value to shareholders, cancelling or downscaling less economical projects, and on reducing operating costs of its supply chain (Shell, 2015).

Sustainable economic performance is not only about ensuring profitable return, but also eliminating the negative environmental and social impacts in supply chain activities. Hence, it is vital for companies to invest in initiatives that can help them address the impacts to ensure long-term survival and growth (Sarkis et al., 2011). The experts think that 'investment in environmental protection' (ECO2) is more important than the 'investment in social assistance initiatives' (ECO3). Environmental investment may be given priority compared to social investment due to the trickle effects of environmental protection strategies on society wellbeing. For example, energy efficiency improvement as well as air and water emissions control measures can also benefit the local communities that are affected by the O&G industry operations. Nevertheless, it is important to stress that there should be real efforts by companies to prevent local communities from shouldering most of the environmental and social cost of the O&G development, and for effective distribution of its economic benefits (Harris and Khare, 2002, Wagner and Armstrong, 2010).

Second: competition

Table 4.6 shows the five sources of competition that we used to measure the factor. The results indicate that the IOCs are the main source of competition, followed by the NOCs. Generally, the main sources of competition are from the O&G industry players and resources, less so from the alternative energy. It appears that the respondents think the emergence of alternative energy companies may not threaten the O&G companies so much so that they are compelled to improve their supply chain sustainability to compete. Rather, the competition within the industry itself will encourage them to operate more sustainably.

Table 4.6 – The sources of competition in the O&G industry

Sub-criteria	Weight	Rank	ξ	CR
Alternative energy development (COM1)	0.19	4	0.62	0.22
Unconventional O&G development (COM2)	0.21	3		
National O&G companies (COM3)	0.22	2		
International O&G companies (COM4)	0.27	1		
Other energy companies, i.e. alternatives energy (COM5)	0.11	5		

The strategic importance of the O&G has increased the competition to access the reserves where about 80% of them are concentrated in three areas namely Russia, the Persian Gulf and West Africa (Xu, 2008); about 75% of the world's reserves are owned by the NOCs (Mitchell and Mitchell, 2014). The IOCs can gain access to these reserves that are controlled by their respective governments only through cooperation with the NOCs.

Despite this shortcoming, the IOCs have more strategic choices because, unlike the NOCs, the companies have more liberty to choose their projects and sell hydrocarbon assets (Mitchell and Mitchell, 2014). In order to maximize their share of O&G reserves, the IOCs have to develop new areas that are beyond the control of the NOCs. The companies are generally more technologically advanced, and their expertise in niche O&G segments such as the unconventionals give them a competitive advantage over the NOCs (Edwards et al., 2010).

The competition between the IOCs and NOCs can actually be a good driver to achieve a more sustainable O&G supply chain. Edwards et al. (2010) suggest that in order to gain access to O&G reserves and compete with other O&G players, IOCs will employ partnership approach that is customized to the local needs of the countries that own the resources. For example, governments may require that IOCs employ or purchase a percentage of services and goods from local suppliers as part of O&G project licensing agreement. Ngoasong (2014) find that IOCs will adopt a business case for local contents strategy and incorporate CSR initiatives of community participation as well as capability building as part of the strategy. Although local contents strategy often benefits well-established businesses, it enables local businesses to enhance their cultural capital (e.g. knowledge on HSE requirements of O&G industry) and social capital (e.g. networking capability).

Compared to IOCs, NOCs are in a better position to understand local issues that can affect the sustainability of O&G development in their home countries. Therefore, in this regard NOCs and IOCs could be complementary partners where NOCs could provide access to the resources and local knowledge, while IOCs could provide the technical and managerial expertise. This in turn could facilitate the employment of a more collaborative strategy towards achieving sustainable supply chain performance. The results of BWM analysis show that the difference in weights between IOCs and NOCs are not large. This could indicate the interdependence of these two groups of companies in O&G development.

Third: political stability

As mentioned earlier in Chapter 2, there are two sources of political risk namely societal sources and governmental sources. As shown in Table 4.7, our analysis reveals that government policies and priorities could affect company ability to implement sustainable O&G development strategy most, i.e. 'shifting economic priorities of government' (POL4) and 'uncertainty in government's energy policies' (POL5). However, it is important to note that the weight of 'opposition to company activities due to environmental issues' (POL2) is just slightly lower than POL4 indicating the potential adverse effect of inadequate environmental protection on company ability to operate smoothly. Again, the respondents think that the instability caused by social aspects, as in POL1 and POL3, could have the least effect on SSCM practices in the O&G industry compared to both the economic and environmental related issues.

Table 4.7 – The sources of political risks to O&G development

Sub-criteria	Weight	Rank	ξ	CR
Political unrest (POL1)	0.12	4	0.59	0.22
Opposition to company activities due to environmental issues (POL2)	0.23	3		
Opposition to company activities due to social issues (POL3)	0.12	5		
Shifting economic priorities of government (POL4)	0.24	2		
Uncertainty in government's energy policies (POL5)	0.29	1		

Due to the global nature of O&G operations, companies in the industry could experience sustainable development pressure in host countries that are different from their home countries. The political condition in these countries could determine their ability to respond to the pressure. The majority of O&G reserves are located in developing countries that rely on O&G revenues to finance development projects and subsidies (Correljé and van der Linde, 2006, Wolf, 2009). Unstable political conditions could create an uncertain business environment that could affect the local O&G industry expansion, consequently threaten energy security (Urciuoli et al., 2014).

According to Van de Putte et al. (2012), government actions and, consequently, potential risks to oil companies can be determined by factors such as O&G production cash flow,

prospects for additional exploration and development as well as the economic benefits of the activities. The increased nationalization of O&G assets and reserves makes it harder for companies to access reserves, could lead to seize-up of assets, and forced renegotiation of development conditions (Fattouh and Darbouche, 2010). Therefore, the risk of government interference and sudden changes in policy should be minimized early on during planning stages of the structure of O&G project (Van de Putte et al., 2012).

The main concern of both oil exporters and importers is the volatility of oil prices, which complicates future investment plans as well as the implementation of energy policies (Bradshaw, 2009). Government commitment to sustainable development, specifically in terms of combating climate change, will encourage many of them to incentivize low carbon energy technologies. However, the political will to promote sustainable energy development will decrease during low oil prices (Pascual and Zambetakis, 2008).

Compared to other commodities, the countries that are dependent on O&G exports are more likely to experience policy failure that could slow economic growth and social development, leading in turn to political instability and conflicts, together known as the resource curse (Karl, 2007). The public expects their governments to manage revenues generated from O&G development effectively through macroeconomic policies that promote sustainable economic growth, such as programs that stimulate local investments, expand infrastructure and public services, create employment and reduce poverty (Kakonge, 2011). However, often the burdens of delivering such benefits are shifted onto O&G companies due to government mismanagement and failure to employ effective governance of economic and social development, as well as environmental protection (Wagner and Armstrong, 2010). Therefore, political stability is an important factor that can facilitate international O&G development cooperation and build local O&G industry, which in turn will determine the benefits that can be gained from the development.

Fourth: stakeholder pressure

Table 4.8 shows the results of the analysis for the stakeholder pressure sub-criteria.

Table 4.8 – Importance of stakeholder involvement

Sub-criteria	Weight	Rank	ξ	CR
Suppliers (STH1)	0.13	4	0.16	0.20
Governments (STH2)	0.28	1		
Shareholders (STH3)	0.19	2		
Local communities (STH4)	0.08	6		
Education institutions (STH5)	0.06	7		
Competitors (STH6)	0.15	3		
Non-governmental institutions (STH7)	0.11	5		

In this study, we used stakeholder involvement as a proxy for the pressure that they exert on a company. It is not surprising to discover that the involvement of ‘government’ (STH2), to quite a large extent, is the most important followed by ‘shareholders’ (STH3). An interesting finding is however, the involvement of ‘local communities’ (STH4) is the second least important compared to other stakeholders. Perhaps another interesting finding, or rather discouraging, whichever way we choose to see it, is to know that the academic experts themselves ranked the involvement of ‘education institutions’ (STH5) as the least important in helping companies to be more sustainable. Granted, academic institutions are not company stakeholder in the strictest sense, but the finding might indicate the extent to which the respondents think academics could influence the industry’s practices.

Based on the results, we could see the influence of power in determining the importance of stakeholder involvement. Without doubt, governments as resource holders and policy-makers

play a major role in determining corporate strategy related to sustainable development of O&G. The O&G industry is a truly international industry because companies must adapt to complex sustainable development pressure from their home and host country, and global stakeholders (Escobar and Vredenburg, 2011). Contradictory stakeholders expectations and direct conflicts with business practices are often the factors that complicate the efforts to address the pressure (Repsol, 2011, OMV, 2011, ExxonMobil, 2011).

Mitchell et al. (1997) suggest that power, legitimacy and urgency could determine the priorities given to competing stakeholder claims. Generally, the claim of a stakeholder that has more power such as government could be prioritized over more urgent and legitimate claim from local communities that have less power to negotiate the claim (Mitchell et al., 1997). Therefore, failure to identify and engage with their stakeholders in a way that creates enduring and mutually beneficial relationship is detrimental to sustainable development of O&G.

A case in point is Shell and Ogoni, an indigenous community in Nigeria, that resulted in tragic loss of lives, damaged reputation and costly disruptions due to inadequate actions by Shell in addressing the human rights, economic and environmental effects of its activities (Wheeler et al., 2002). Although O&G companies are increasingly involved in corporate social responsibility (CSR) practices to address this problem, the efforts failed to give long-term benefits to affected communities (Frynas, 2005). This is due to the lack of attention on country and context-specific issues, involvement of beneficiaries of CSR, and integration of CSR initiatives into overall company development plan. Matos and Silvestre (2013) suggest that an integrative approach to stakeholder engagement and collaboration is needed. The strategy must incorporate both supply chain members and other stakeholders to facilitate better learning opportunities and solutions in addressing sustainability issues in supply chain.

Fifth: regulations

Seuring and Müller (2008) found that regulation is one of the most often cited factors in the literature as important influence to SSCM practices. In this study, it is ranked as the second least important factor. This is rather consistent with Sharma's (2001) findings that other external factors, such as stakeholder and market pressure, and internal factors, such as continuous improvement practices, are more important in driving environmental sustainability. Leading companies were found to implement environmental measures that are beyond regulatory requirements (Sharma, 2001, Ford et al., 2014). Regulations, however, are important as initial guidelines and benchmark for minimum standards of good practice in environmental management strategy (Sharma, 2001). Table 4.9 shows the results of the analysis of the regulations sub-criteria that focus on environmental and social sustainability. The results indicate that cost factors could play the most important role in determining how the O&G industry addresses regulatory pressure.

Table 4.9 – Importance of regulatory pressure on SSCM of O&G development

Sub-criteria	Weight	Rank	ξ	CR
Uncertainty of current regulatory framework for emissions reduction (REG1)	0.30	2	0.41	0.17
Changes to compliance mechanism related to SHE protection (REG2)	0.23	3		
Cost related to compliance and remediation (REG3)	0.34	1		
Regulations on materials use (REG4)	0.13	4		

The cost of regulatory compliance vary widely which is especially disadvantageous to smaller companies (Harris and Khare, 2002). For example, the initial compliance and further increase of stringency of air quality regulations for refinery cost about $3 million and $5 million per plant, respectively (Berman and Bui, 2001). After the BP Deepwater Horizon oil spill accident in 2010, a Drilling Safety Rule was introduced to prevent blowout during

drilling operations on Outer Continental Shelf (OCS). The estimated yearly cost increase due to the regulation requirements for each operator is approximately $183 million (McAndrews, 2011), which could make many O&G development projects to be commercially infeasible (Harsem et al., 2011). Sharma (2001) suggests that the real regulation-related costs are the cost of non-compliance since companies can be subjected to costly sanctions and fines, as well as community backlash that could damage reputation and disrupt operations.

Concern about the impact of carbon emissions on the environment is one of the most difficult challenges that the O&G has to address. The regulatory uncertainty related to emission reduction is ranked as the second most important factor by the respondents. According to Levy and Kolk (2002), the O&G industry can be affected by uncertainties with regard to the future of climate science, emission regulations and alternative technologies. A carbon market was introduced under the Kyoto Protocol to enable countries with commitments to the protocol to meet their targets in reducing or limiting GHG emissions. However, its implementation among the countries are evolving at different phase, therefore remain uncertain and incomplete (Levy and Kolk, 2002, Wagner and Armstrong, 2010, Waisman et al., 2014), making it difficult for the O&G industry to assess its business impacts.

Apart from participating in the carbon markets, the O&G industry is putting significant effort into finding technological solutions for carbon management in operations as well as along the supply chain, for example through energy efficiency improvement measures and carbon capture and storage. Major attention is also given to the development of natural gas as cleaner alternative to oil as the industry transitions itself toward low carbon energy systems. Ford et al. (2014) find that collaboration with supply chain partners can help companies in the O&G industry to find innovative solutions to respond to regulatory pressure.

Sixth: energy transition

The least important external factor that could affect SSCM practices in the O&G industry is the transition to low carbon energy. In this study, we used policy related sub-criteria to measure the factor as shown in Table 4.10.

Table 4.10 – Importance of policy measures for energy transition

Sub-criteria	Weight	Rank	ξ	CR
Policies that promote a level of playing field for energy players (ETR1)	0.13	4	0.50	0.19
Imposition of fiscal, taxation or other measures to promote low-carbon/ renewable energy (ETR2)	0.36	1		
Policy to encourage investment in energy efficiency to reduce O&G demand (ETR3)	0.31	2		
Transitional support to alternative energy as an ongoing subsidy to reduce carbon emissions (ETR4)	0.20	3		

Our analysis reveals that fiscal instruments can be the most important factor that drives alternative energy development. The instruments such as subsidies and tax exemptions could generate market forces, especially for energy sources that face biased market behaviour, and provide the incentives for the existing and new energy players to be involved in the development (Roy et al., 2013). Fiscal policy is also used to encourage the actors in the incumbent fossil fuel-based energy regime to alter their behaviour and implement sustainability measures that could help the transition to low carbon system (Roy et al., 2013). However, inconsistent government policy could result in huge losses to companies. For example, Exxon lost $500 million when a change of government resulted in discontinuation of subsidy to renewable energy given by the previous administration (Levy and Kolk, 2002).

Although O&G companies are showing their interest in the development of renewable and low carbon energy, it is apparent that O&G will remain the major focus as seen by the

increasing development of natural gas and unconventional O&G. Csomos (2014) found that O&G companies such as ExxonMobil, Chevron, Shell and Total recognize the importance of renewable energy and have invested in, for example, biofuel, wind and solar power development, but most stress that only O&G could fulfill the world's growing energy demand. Subsidies given to fossil fuel generate market failure bacause renewable and low carbon energy will be seen as costlier options, which will affect their ability to gain a substantial increase in market share.

The use of policies that reallocate subsidies from fossil fuel based technology without carbon capture and storage, emission reduction regulations and carbon pricing could help address the distortion in the fiscal incentives (Roy et al., 2013). This could encourage investment in energy efficiency technologies to reduce dependency on energy from O&G sources and address the environmental impacts of energy consumption. Examples of such technologies include low-emissity windows and LED lamps in buildings, smart meters and control systems to monitor electricity use (IEA, 2015), low rolling resistance tyres as well as hybrid and electric cars (Kojima and Ryan, 2010). We found that the introduction of policies that encourage investment in energy efficiency is the second most important factor that could affect the O&G industry during energy transition.

The factor that could be, to a certain extent, a game-changer in the O&G industry is company willingness to forego economic opportunities of oil because of climate change concerns. The companies in the O&G industry generally share similar competencies and strategies in their core business (Levy and Kolk, 2002). Since O&G products are static and have very little variation, the companies have very few options to help them gain competitive advantage in the market. Involvement in alternative energy could provide a company the first-mover advantage, thus positioning itself better for future energy systems.

According to Escobar and Vredenburg (2011), O&G companies employ two strategies in the development of alternative energy and technologies:

1. Development of firm-specific capabilities and deployment of green consumerism strategy to generate profit, e.g. Shell develops transport technologies based on biofuel and hydrogen, as well as wind and thin-film solar renewable sources; and
2. Development of incremental and complementary technologies, e.g. Chevron develops hydrogen fuel cell technology from natural gas.

Although the development of alternative technologies is relatively slow, energy sources such as biofuel could benefit from the technological learning curve of O&G development and economies of scale of its integration with existing infrastructure (Szklo and Schaeffer, 2006). O&G companies' involvement in alternative energy will also help them to gradually green their supply chains and transition themselves towards low carbon energy systems.

We have discussed the results of the analysis of all criteria and their corresponding sub-criteria earlier in this section. We used the resulted weight of the sub-criteria to calculate their global weight to see the relative importance of each of the sub-criteria to each other, shown in Table 4.11.The result of the global weight analysis generally shows that the most important sub-criteria of the external factors that could affect SSCM practices are those related to economic factor, government policy, cost of doing business and competition within the O&G industry.

Table 4.11 – The global weight of all sub-criteria (in descending order)

Criteria	Global weight
Capital investment program (ECO1)	0.176
Investment in environmental protection program (ECO2)	0.116
International O&G companies (COM1)	0.046
Uncertainty in government's energy policy (POL5)	0.044
Investment in social assistance program (ECO3)	0.043
Cost related to compliance and remediation (REG3)	0.039
National O&G companies (COM2)	0.038
Imposition of fiscal, taxation or other measures to promote low-carbon renewable energy (ETR2)	0.037
Governments (STH2)	0.036
Unconventional O&G development (COM2)	0.035
Shifting economic priorities of government (POL4)	0.035
Uncertainty of current regulatory framework for emission reduction (REG1)	0.035
Opposition to company activities due to environmental issues (POL2)	0.034
Alternative energy development (COM1)	0.033
Policy to encourage investment in energy efficiency to reduce O&G demand (ETR3)	0.032
Changes to compliance mechanism related to SHE protection (REG2)	0.027
Shareholders (STH3)	0.025
Transitional support to alternative energy as an ongoing subsidy to reduce carbon emission (ETR4)	0.021
Competitors (STH6)	0.020
Other energy companies, i.e. alternative energy (COM5)	0.018
Political unrest (POL1)	0.018
Opposition to company activities due to social issues (POL3)	0.017
Suppliers (STH1)	0.016
Regulations on materials use (REG4)	0.016
Policies that promote a level playing field for energy players (ETR1)	0.014
Non-governmental institutions (STH7)	0.014
Local communities (STH4)	0.010
Education institutions (STH5)	0.008

We will present the conclusion and implications of this study in the following section.

4.4 Conclusion and implications

In this study, we find that economic stability is the most important factor that could affect the sustainability of the O&G supply chain. The dependency between economic development and the O&G industry has been the subject of many studies, but very few tried to investigate their relationship with regard to SSCM practices in the industry. Our attempt to contribute to the discussion on this issue through BWM, is able to shed some light on its importance to SSCM practices in the O&G industry. On the other hand, it is limited in a sense that further empirical work is needed to identify how economic (in)stability could affect SSCM practices.

Our analysis reveals that there is a consensus among academic experts that stable economic conditions are an important prerequisite that allow companies to spend resources beyond ensuring their economic sustainability. Economic downturn could result in a reduction of oil prices that affects revenues, thereby forcing a company to tighten its spending on O&G development and sustainability related initiatives. In such instances, selective investment measures are needed to ensure financial efficiency and allow the company to maintain itself. However, it is important to ensure that the measures will not compromise its commitment toward sustainable practices such as in health, safety and environmental protection.

We also find that stable regulatory pressure is less important in driving SSCM practices in the O&G industry compared to competition, political stability and stakeholder pressure. This

finding could suggest that a company would seek to improve its supply chain sustainability even in less stringent regulatory environment to gain competitive advantage and to secure legitimacy as responsible corporate citizen. A stable economic and political environment would provide a more conducive environment that can help the company to focus available resources on improving its SSCM practices. The least important external force is energy transition. We attribute this finding to the slow growth rate of alternative energy that poses little urgency to O&G companies to compete based on sustainability factors. In addition, the O&G companies themselves may be benefitting from the policy supports given to help the development of the alternative energy to start their own projects and build their expertise in alternative technologies.

Sustainable development is, in essence, a strategic problem. This is especially more pronounced when we consider the role that the O&G industry plays in the achievement of sustainable future and its interrelationship with the forces within the industry's business environment. The external factors are, to large extent, beyond company control. In order to address the pressure to operate sustainably, companies in the industry must utilize their internal capabilities to overcome this issue. This could be through proactive monitoring of risks related to, for example, global economic development that could affect investment commitments, changes in regulatory requirements for environmental and social protection, political conditions of host countries. Ability to manage risk proactively is crucial in identifying threat in the business environment so that timely actions can be taken to avoid costly disruptions in supply chain that can threaten energy security, causing adverse impact on the environment, and damaging company image.

O&G companies must also adopt stakeholder engagement strategies that could help them exploit the opportunities and manage the risks that are present due to the interactions between the external factors. However, often the practices of stakeholder consultation in the O&G industry are criticized as inadequate due to the lack of involvement of the stakeholders that are directly affected by the industry's activities such as local communities. The practice is especially lacking in countries with authoritarian government and weak civil societies. Local communities may not have enough power to voice their concerns or unable to do so due to barriers to communication, or inadequate engagement strategy by company itself that fails to consider local realities. Therefore, more integrative stakeholder engagement is needed to exploit the synergies that could result from the cooperation between policy makers, industry peers, interest groups and communities to achieve sustainable supply chain. In addition, close cooperation with supply chain partners such as suppliers, service providers, contractors and other operators is crucial. This is to ensure that a company could benefit from the supply chain dynamics and interrelationship to address uncertainties caused by for example, stakeholder expectations that are in conflict with business economic objectives.

A limitation of our findings in this study relates to the use of a survey among academic experts to understand the importance of the external forces to SSCM practices. It can be argued that their understanding of the realities of the O&G business environment and SSCM implementation might be limited, which could consequently affect their judgment. Although building on academic research based knowledge is a valid alternative to industry experts (Rezaei et al., 2012), a study using data gathered from the industry could result in different findings. Therefore, more studies should be conducted to investigate this issue further based on industry experts' opinions. This will allow us to compare findings gathered from academic and industry perspectives, thus help reduce the gaps between theory and practice.

BWM helps us to identify the importance of external factors towards SSCM practices in the O&G and rationalize the effect that the factors could have on the practices. The BWM method could help a company to determine how changes in the priorities given to each external factor could influence decision-making processes. However, it is important to note

that the use of BWM alone might be insufficient in understanding complex issues such as the one investigated in this study since each of the external factors is not affecting the O&G industry in isolation. Therefore, this method should be followed by more in-depth analysis of the issues, for example through case studies.

Overall, in this chapter we identified the importance of external factors to the adoption of SSCM practices in the O&G industry based on data obtained from academic experts. The next chapter examines the relationship between the factors and supply chain sustainability goals using data gathered from an industry survey. We argue that the development of internally consistent sustainability goals could help the alignment of companies' internal organizational environment with the external environment towards a more sustainable supply chain performance.

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5. The Influence of External Factors on Supply Chain Sustainability Goals

This chapter is based on: Wan Ahmad, W.N.K., Rezaei, J., De Brito, M. P. and Tavasszy, L.A. (2016), "The influence of external factors on supply chain sustainability goals of the oil and gas industry", Resources Policy, Vol. 49, pp. 302-314.

5.1 Introduction

There are various studies related to the external factors that could affect the O&G industry such as energy geopolitics (Bradshaw, 2009), competition (Xu, 2008), and regulations (Wagner and Armstrong, 2010). However, none of them discusses these issues in the context of sustainable supply chain management (SSCM) practices in the industry. This gap should be addressed because every company or industry operates in a particular context that could influence its activities (Gillespie, 2011). The best way for the company or the industry to organize itself, therefore, is contingent upon the environment in which it operates (Galbraith, 1973). The same could be assumed regarding the factors that could affect the implementation of SSCM practices in the O&G industry.

The goal of SSCM practices is to achieve a joint optimization of the long term economic, environmental and social performance of individual companies and their supply chains (Carter and Rogers, 2008). Companies need clear and internally consistent sustainability goals that can guide their implementation of SSCM strategy. This is to ensure that their internal capabilities and resources can be used effectively to achieve the goals and address the pressure to operate sustainably throughout supply chain. It would also help companies to measure the performance of their SSCM practices against the goals that they set to enable continuous improvement of the practices (Schaltegger and Burritt, 2014).

In this chapter, we aim to explore the relationship between the external factors discussed in the previous chapters and supply chain sustainability goals, arguing that this will determine the sustainable supply chain strategies adopted by companies. The research questions for this chapter are formulated as follows:

1. *What are the supply chain sustainability goals of companies in the O&G industry?*
2. *What are the relationships between external factors and the sustainability goals?*
3. *How can the external factors affect companies' focus on the goals, thus their sustainable supply chain strategy?*

Insights gained from answering these questions could help us to increase our understanding of the role that the external factors play in driving (or hindering) SSCM implementation in the O&G industry. It could also help companies in the industry to identify the internal capabilities and resources that must be developed or improved to address the pressure from the factors to achieve their sustainability goals. This would facilitate the development of an SSCM strategy that considers the opportunities and threats within companies' external business environment as well as the internal organizational strength and weaknesses towards more effective implementation of the strategy.

This chapter is organized as follows. Section 5.2 reviews the literature related to goals of SSCM. It is followed by Section 5.3 that discusses the important sustainability issues in the O&G industry. Section 5.4 describes the research methodology employed. This is followed by Section 5.5 that discusses the results of data analysis. Finally, section 5.6 concludes this chapter with the main findings and implications of this study.

5.2 Goals of sustainable supply chain management

In light of greater public interest in the sustainability of the O&G supply chain, it is apparent that companies in the industry must seek to balance profitability with environmental and social responsibility. The industry's external environment consists of various factors that can influence their ability to achieve the balance. It is therefore important for the companies to set clear sustainability goals to guide their supply chain management practices.

A review of the literature suggests that sustainability goals are often discussed in relation to the ultimate aim of SSCM, which is to design and implement supply chain solutions that can achieve balanced economic, environmental and social performance. Seuring and Müller (2008) found three categories in which these sustainability dimensions relate to each other in terms of their goal relations: win-win situations, trade-offs and minimum performance. In addition, the discussions on sustainability goals also revolve around their integration in corporate and functional supply chain strategy (Wolf, 2011, Harms et al., 2013, Beske, 2012), use as indicators for performance measurement and management of SSCM (Wittstruck and Teuteberg, 2012, Darnall et al., 2008), and development of strategic resources and capabilities (Paulraj, 2011).

Azzone and Noci (1998) find that the integration of sustainability into an organization's activities can be facilitated by linking sustainability goals and measures to corporate strategy. In order to create a sustainable chain, managers must also integrate sustainability goals into day-to-day supply chain management (Pagell and Wu, 2009). In a study on performance measurement system for green supply chain management (GSCM), Hervani et al. (2005) stress that the overall goal of the system must be defined right in the beginning of its design stage. Identification of sustainability goals early in the process is important in the measurement and management of supply chain performance (Schaltegger and Burritt, 2014, Hervani et al., 2005).

These studies point out the role of sustainability goals as a foundation that the SSCM strategy is built upon. However, sustainability goals are seldom explicitly incorporated in an SSCM framework or design as a distinct factor that could influence strategy formulation or be affected by other factors within business and organizational environment. In one of the rare

studies that did so, Pagell and Wu (2009) include alignment of environmental, social and economic goals as a measure of managerial orientation towards sustainability. They find that commitment to sustainable practices and integration of the practices in supply chain management are evident through alignment of economic with noneconomic goals. Another study conducted by Hervani et al. (2005) proposed a framework that incorporates vision and goals as an input to GSCM performance measurement system design.

Besides the lack of attention on sustainability goals, the common theme among all of the studies discussed thus far is that they are all internally focused. Carter and Rogers (2008) assert that true sustainability occurs when organizations incorporate explicit and comprehensive economic, environmental and social goals in the development of their strategic vision and long-term strategic objectives. Achievement of these goals can be influenced by factors that are within companies' external and internal environment. This underscores the need to identify the factors that can drive or hinder the achievement of the goals (Seuring and Müller, 2008), so that appropriate resources can be allocated and prioritized for effective implementation of SSCM strategy. Compared to the internal factors, the existing SSCM literature offers no empirical evidence on how factors in companies' external environment could determine the set goals.

Porter (1991, p. 96) posits that company success is conditioned by the development and implementation of "internally consistent sets of goals and functional policies". This would enable the integration of various functional departments towards common goals that allow the alignment of its strengths and weaknesses with the threats and opportunities that are present in the external environment (Porter, 1991). Institutional theory recognizes organizations as rationalized systems that strive to achieve their goals through a set of roles and activities (Scott, 2005). When faced with external institutional pressure such as political, economic, social factors or industry norms, organizations would adapt to the changes in the environment to increase their compatibility with the environmental characteristics and to gain social legitimacy (DiMaggio and Powell, 1983, Scott, 2005).

Following this school of thought and the finding that sustainability goals can be perceived as a foundation of SSCM strategy development, it can be assumed that the factors within an industry's external business environment can co-determine the goals that companies pursue. The lack of understanding regarding the relationship between external factors and sustainability goals necessitates that research be conducted to close this knowledge gap. It would, consequently, help us to understand the factors that influence the formulation and adoption of SSCM strategy among companies.

5.3 Sustainability goals of the oil and gas industry

As far as we know, there are no studies that focus on the O&G supply chain's sustainability goals. As goals may not be reported or stated explicitly, we take a first step to gaining an understanding of the goals by identifying the sustainability issues publicly stated to companies' broad base of stakeholders. We argue that these are valid leads to influence the O&G companies' priorities and eventually their sustainability goals.

We referred to sustainability reports of O&G companies since many of them conduct a materiality study among their stakeholders to identify the important issues that should be addressed in their reporting. According to GRI (2015), material topics are those that could (in)directly affect a company's ability to create, preserve or erode the triple bottom line value – economic, environment and social – of the company itself, its stakeholders and the broader society.

We examined the 2010 sustainability reports of 12 major companies in the O&G industry[2]. Overall 97 separate issues were identified through the materiality study. Sixteen issues are identified as having the strongest replication across the 12 companies, which are summarized in Table 5.1.

Table 5.1 – Material sustainability issues to O&G companies and their stakeholders

	Company											
Issues	ADN	ENI	HES	KNO	MIT	ONG	OMV	PEM	PET	ROS	SAS	TNK
Community development	x	x	x	x	x	x	x	x	x	x		x
Environmental management	x	x	x	x	x	x	x			x		x
Occupational health & safety	x	x	x	x		x	x				x	x
Climate change			x	x	x	x	x	x			x	
Resource efficiency	x	x			x	x	x	x			x	
Transparency		x	x	x				x	x	x		x
Stakeholder involvement		x	x				x		x	x		x
Employee training & education	x	x	x			x				x		x
Suppliers/ contractors management			x	x		x	x	x		x		
Air emissions	x	x					x		x			x
Energy security				x		x	x				x	
Product responsibility	x					x	x			x		
SHE management systems		x						x		x	x	
Energy transition						x	x		x			
Innovations	x			x					x			
Transport safety							x			x		x

The most important issue is the impact of company activities on local community's social and economic wellbeing (i.e. community development). It is quite interesting to note that energy transition, specifically the development of alternative energy, is among the least important issues despite the growing political and public attention on the issue. Sustainability of logistics activities is hardly mentioned as important as well; logistics issue that is considered as important largely concerns about transport safety.

Further analysis of the important issues leads us to identify supply chain sustainability goals that should be investigated. In this study, we chose to focus on goals that could directly influence the sustainability of supply chain management practices. Therefore, goals related to broader corporate social responsibility (CSR) initiatives namely training and education and community development are not included. The goals that we focus on are as follows:

1. Safety, health and environmental (SHE) management
2. Resource efficiency
3. Transparency of sustainability reporting
4. Guidance to stakeholders on company operations
5. Sustainability of supply management practices
6. Energy security
7. Product responsibility
8. Sustainability of logistics activities
9. Development of unconventional O&G
10. Development of alternative energy

[1] Abu Dhabi National Oil Companies (ADN), Eni (ENI), Hess Corporation (HES), Korean National Oil Corporation (KNO), Mitsubishi Corporation (MIT), Oil & Natural Gas Corporation (ONG), Petroleos Mexicanos (PEM), Petrobras (PET), Rosneft (ROS), Sasol (SAS) and TNK-BP (TNK).

Even though the development of unconventional O&G and alternative energy are not among the most important issues, they are included in the study due to the importance of these sources in the current debates about energy transition and energy security (Fouquet, 2010, Szklo and Schaeffer, 2006). The O&G industry's involvement in the development of these energy sources will require changes to their technological and infrastructure needs as well as their supply bases. It is therefore important to include them in the contextual study of SSCM practices in the industry.

In summary, the discussion above reveals the various sustainability issues that companies have to deal with. The literature provides little insights into the relationship between external factors and sustainability goals of companies in the O&G industry. Empirical research can help to address this gap, as it will help us to understand the importance of the factors that drive (or hinder) company focus on a goal, and eventually its achievement.

5.4 Methodology

This section discusses the survey that was held to empirically investigate the relationship between sustainability goals and external factors.

A survey among companies involved in the O&G supply chain was conducted to test the relationship between external factors (i.e. political stability, economic stability, stakeholder pressure, competition, energy transition and regulations) and sustainability goals. We did not restrict our population to a specific country or region because the study involves understanding supply chain contextual environment in a more fundamental sense. A broader population was necessary to gain this understanding.

Most of the existing studies related to SSCM of O&G focus on specific segments of the supply chain. In this study, companies that operate along different segments of the O&G supply chain are chosen to ensure that all of the industry's subsectors are considered. The main segments to consider include (1) the upstream segments, involved in exploration and production of crude O&G and (2) the downstream segments that produce, market and distribute various refined petroleum products to consumers. We draw our sample from the Kompass database, using purposive random sampling, to select companies from both the upstream and the downstream segments.

We developed a questionnaire based on the reported review of literature and sustainability reports of O&G companies, using the six categories of external factors and the supply chain sustainability goals, as discussed earlier. We consulted academic experts in the areas of the O&G supply chain, SCM and survey methodology to review and improve the questionnaire. The questionnaire was then pre-tested with experts from three O&G companies through personal interviews and emails. Further items were revised after the pre-test. In the end 29 measurement items of the external factors (six questions, overall) and ten supply chain sustainability goals' measurement items (one question) were retained. We used a 6-point Likert scale ("not at all" to "very high") to measure all items except for the items on the political variable, where we used a 5-point Likert scale ("never" to "very often")[3]. Please refer to Appendix III for the full questionnaire, which also include the measurement items for internal factors and sustainable supply chain strategies that will be discussed in the next chapter.

[3] We standardized the two Likert scale so that both use similar 1 to 5 intervals.

5.4.1 Data collection

We employed both online and mail-based methods to send the questionnaire to senior managers of our sample companies. Supply chain or sustainable development managers were chosen when the contact information was provided in the companies' websites; otherwise the emails/letters were addressed to the chief executive officer or the managing director. Senior managers were chosen to reduce the potential for one-respondent bias in the survey. We assumed that the senior managers have a good understanding of their companies' activities and are able to access the information needed to answer the questionnaire.

A large number of surveys had to be sent out, with different rounds of follow-up, over a period of 6 months, to reach an acceptable response. Initial invitations were sent by e-mail for an online survey to 4300 companies. Due to slow responses from the online survey, we then sent mail-based survey to 800 companies to increase the response rate.

The online survey yielded 71 responses, of which 60 were usable. The mail survey returned 36 questionnaires, 34 of which usable. Overall, there are 94 valid questionnaires out of 107 responses received that can be used to test the relationship between external factors and supply chain sustainability goals. The response rate is low, but we think that this is a sufficient sample to test the relationship considering the difficulty in getting adequate responses in studies specific to the O&G supply chain (see for example, Andersen and Mostue, 2012, Yusuf et al., 2013).

The profiles of the respondents of our survey are as shown in Table 5.2.

Table 5.2 – Profile of respondents

Criteria	Total	Percentage
Job title		
Chairman of the Board/ President/ Chief Executive Officer/ Managing Director	20	21.28
Executive Vice President/ Chief Financial Officer/ Chief Operating Officer	3	3.19
Vice President/ Director/ General Manager	14	14.89
Manager	22	23.40
Others	13	13.83
Missing	22	23.40
Years working for company		
Less than 5	22	23.40
6 – 10	23	24.47
11 – 15	13	13.83
More than 16	22	23.40
Missing	14	14.90

Table 5.3 shows the characteristics of the companies that responded to our survey invitation.

Table 5.3 – Sample characteristics

Criteria	Total	Percentage
Business Sector*		
Upstream (i.e. exploration and production)	37	39.36
Downstream (i.e. refining, petrochemicals, power producer)	29	30.85
Manufacturer/supplier/service provider	67	71.28
Missing	12	12.77
Number of employees		
Less than 1,000	53	56.38
1,001 – 5,000	8	8.51
5,001 – 10,000	8	8.51
More than 10,000	12	12.77
Missing	13	13.83
Annual turnover		
Less than $250 million	44	46.81

Criteria	Total	Percentage
$250 - $500 million	5	5.32
$501 - $750 million	2	2.13
$751 - $1 billion	4	4.26
More than $1 billion	25	26.60
Missing	14	14.89
Number of countries a company operates in		
Less than 15	60	63.83
16 - 30	8	8.51
31 - 45	4	4.26
More than 45	9	9.57
Missing	13	13.83
Involvement in industry network*		
International Association of Oil & Gas producers (OGP)	13	13.83
The World Petroleum Council (WPC)	7	7.45
The World Energy Council (WEC)	5	5.32
International Petroleum Industry Environmental Conservation Association (IPIECA)	5	5.32
European Oil Company Organization for Environment, Health and Safety (CONCAWE)	3	3.19
International Association of Drilling Contractors	3	3.19
Global Reporting Initiative	2	2.13
Global Compact	2	2.13
American Petroleum Institute	2	2.13
Other networks	32	34.04
Missing	66	70.21

* The total percentage is more than 100% because a company may be involved in multiple O&G business sectors and industrial networks

Generally, five of the companies operate in both upstream and downstream supply chain. Fifteen companies, approximately 16% overall, that are involved in the upstream and/or downstream segment also serve as manufacturer, supplier or service provider. The majority of the sample operates in Europe (66%) and Asia (41%). About 31% are involved in the O&G development in the Middle East, 21% in North Africa and 32% in North America.

5.4.2 Data preparation

Before proceeding with further analysis, we checked the data gathered for the potential of non-response bias. The analysis was done by comparing the responses from the first wave of the online and mail survey with the second wave of responses from both approaches based on Armstrong and Overton (1977) suggestion. Specifically, the first two thirds of the responses from the online and mail survey are considered as the first wave, while the remaining responses are considered as the second wave. The difference in the responses between the two waves was analyzed using a *t*-test. The results shown in Table 5.4 indicate that there are no significant differences between the two waves of responses.

Table 5.4 – *t*-Test results for non-response bias

	t-test for Equality of Means		
	t	df	Sig. (2-tailed)
Number of countries a company operates in	1.26	78	0.28
Size	-1.63	78	0.11
Revenue	-1.53	78	0.13
Extent of activities in O&G supply chain	-1.05	78	0.30

An exploratory factor analysis was conducted to reduce data and also to derive groupings of items used to measure the external factors and supply chain sustainability goals. The factors were extracted using the principal component method, followed by a varimax rotation. Based on the results of the factor analysis, we retained factors with eigenvalues that are

greater than one, as suggested by Hair et al. (2010), because each factors must account for the variance of at least a single variable. For practical significance, factor loadings that are greater than ±0.50 were also used as a threshold in the selection criteria (Hair et al., 2010). The results of the factor analysis, together with the Cronbach's alpha value of each extracted factor, are shown in Table 5.5.

Table 5.5 – Results of exploratory factor analysis for all items

Variable		Measurement items	Factor loading	Cronbach's alpha
External factors	Government-induced political stability (PGO)	Uncertainty in government's energy policies	0.72	0.86
		Shifting economic priorities of government	0.63	
	Society-induced political stability (PSO)	Opposition to company activities due to social issues	0.85	0.77
		Political unrest	0.74	
		Opposition to company activities due to environmental issues	0.61	
	Economic stability (ECO)	Investment in environmental protection programs	0.86	0.91
		Capital investment program	0.83	
		Investment in social assistance programs	0.79	
	Stakeholders pressure (STH)	Education institutions	0.78	0.88
		Suppliers	0.77	
		Governments	0.70	
		Non-governmental organizations (NGOs)	0.68	
		Competitors (i.e. other industry players)	0.68	
		Local communities	0.67	
		Shareholders	0.57	
	Competition within O&G industry (COG)	National O&G companies	0.86	0.98
		International O&G companies	0.86	
		Unconventional O&G development	0.53	
	Competition from broader energy industry (CEN)	Alternative energy companies	0.78	0.85
		Companies other than O&G operators/producers	0.75	
		Alternative energy development	0.69	
	Energy transition (ETR)	Transitional support to alternative energy as an ongoing subsidy to reduce carbon emissions	0.85	0.97
		Policy to encourage investment in energy efficiency to reduce O&G demand	0.82	
		Policies that promote a level playing field for energy players	0.81	
		Imposition of fiscal, taxation or other measures to promote low carbon/renewable energy	0.75	
	Regulations (REG)	Changes to compliance mechanism related to health, safety & environmental protection	0.82	0.93
		Cost related to compliance and remediation	0.79	
		Regulations on materials use	0.69	
Supply chain sustainability goals	Strategic goals (SGO)	Provide guidance on company's operations to stakeholders (GUI)	0.84	0.85
		Transparency of sustainability performance reporting (TRA)	0.83	
		SHE management (SHE)	0.77	
		Energy security (ENS)	0.61	
	Functional goals (FGO)	Product responsibility (PRO)	0.86	0.82
		Sustainability of logistical activities (LOG)	0.86	
		Sustainability of supply management practices (SUP)	0.81	

The analysis of the external factors revealed the existence of eight separate factors. One item from the initial group of measurement items loaded on two different factors indicating that the item can represent different concepts, therefore cannot be distinguished (Hair et al., 2010). The item was deleted due to the cross-loading and also because it had a factor loading below 0.5. We found that the political construct consists of two factors that can be distinguished as (1) 'government-induced political stability' (PGO), and (2) 'society-induced political stability' (PSO). The competition construct also consists of two factors that we labelled as: (1) 'competition from within O&G industry' (COG) and (2) 'competition from broader energy industry' (CEN). We retained all of the eight factors because the different underlying factors of political stability and competition might lead to interesting findings regarding their relationship with sustainability goals.

As for the measurement items of supply chain sustainability goals, we removed three of the items based on the result of the factor analysis. Two of the items are the development of unconventional O&G and alternative energy which are not among the material issues found in the companies' sustainability report. The deletion resulted in two supply chain sustainability goal factors which we categorized as 'strategic goals' (SGO) and 'functional goals' (FGO). The SGO items relate to goals that are conditional for long-term survival of a company, while the FGO items are closely related to the companies' operational processes in supply chain management. It is therefore quite interesting that our factor analysis is able to distinguish these two types of supply chain sustainability goals. We retained both of the factors for further analysis because each external factor may have a different relationship with the goals.

Overall, the eight factors identified for the external factors and two supply chain sustainability goal factors explain 75.59% and 74.08% of the inherent variation in their measurement items respectively. As shown in Table 5.5, the Cronbach's alpha (CA) value of all factors are above 0.70, which satisfies the limit accepted to ensure constructs' internal consistency (Flynn et al., 1990).

The use of exploratory factor analysis enables us to also check for the potential of common method bias using Harmon's single-factor test (Podsakoff and Organ, 1986). All of the extracted factors for the external factors and sustainability goals have eigenvalues that are greater than one. In addition, there is no single factor that accounts for the majority of the variance of the two constructs – the first factor of the external factors and sustainability goals account for about 14.78% and 37.99% of variance, respectively. Therefore, the results show that common method variance is not an issue in our study.

A normality test was conducted on all items and variables. The results indicate the existence of various degrees of normality, thus we conclude that the data are able to satisfy the assumption of normal distributions.

5.5 Analysis and results

In this section, we will first describe the external environment of O&G supply chain and companies' sustainability goals based on the results of the descriptive and correlation analysis. Then, we will focus our discussion on the relationship between the external factors with supply chain sustainability goals examined through regression analysis.

5.5.1 External business environment and sustainability goals of the oil and gas industry

Table 5.6 shows the results of descriptive analysis conducted for the measurement items of external factors. The descriptive analysis indicates that the sample companies experience a moderately stable political condition, i.e. infrequent to occasional political-related incidences caused by governmental (PGO) and societal (PSO) sources, in their business environment.

The economic condition (ECO) during the last five years enables them to moderately invest in planned business expansion and sustainability initiatives, indicating a relatively stable economic environment.

Table 5.6 – Results of descriptive analysis for external factors' measurement items[4]

	Mean	Std. Deviation
Government-induced political stability (PGO)	***2.61***	***1.11***
Shifting economic priority of government	2.47	1.17
Uncertainty in government's energy policy	2.76	1.20
Society-induced political stability (PSO)	***1.91***	***0.89***
Political unrest	1.99	1.06
Opposition to company activities due to environmental issues	2.01	1.11
Opposition to company activities due to social issues	1.74	1.03
Economic stability (ECO)	***3.35***	***0.91***
Capital investment program	3.65	0.88
Investment in environmental protection programs	3.33	1.01
Investment in social assistance programs	3.06	1.18
Stakeholder pressure (STH)	***2.92***	***0.88***
Suppliers	3.00	1.09
Governments	3.04	1.18
Shareholders	3.28	1.21
Local communities	3.09	1.32
Education institutions	2.79	1.07
Competitors (i.e. other industry players)	2.74	1.00
Non-governmental organizations (NGOs)	2.50	1.04
Competition within the O&G industry (COG)	***2.55***	***0.98***
Unconventional O&G development	2.24	1.07
National O&G companies	2.71	1.21
International O&G companies	2.69	1.26
Competition from broader energy industry (CEN)	***2.23***	***0.85***
Alternative energy development	2.26	1.07
Other energy companies	2.09	0.92
Companies other than oil & gas operators/producers	2.34	1.15
Energy transition (ETR)	***2.60***	***0.97***
Policies that promote a level playing field for energy players	2.48	1.01
Imposition of fiscal, taxation or other measures to promote low carbon/renewable energy	2.76	1.19
Policy to encourage investment in energy efficiency to reduce O&G demand	2.65	1.09
Transitional support to alternative energy as an ongoing subsidy to reduce carbon emissions	2.51	1.14
Regulations (REG)	***2.86***	***0.93***
Changes to compliance mechanism related to SHE protection	2.95	1.05
Cost related to compliance and remediation	3.03	1.03
Regulations on materials use	2.60	1.20

We find that the extent to which the companies involve their stakeholders (STH) at strategic level in addressing sustainability issues is just slightly below the moderate level; shareholders (3.28), local communities (3.10), governments (3.04) and suppliers (3.00) are consulted most. Mitchell et al. (1997) suggest that companies will prioritize stakeholder groups based on the power that they hold, as well as the urgency and legitimacy of their claims. Kolk and Pinkse (2007) found that companies' stakeholder engagement strategy depends on the extent of stakeholder control over critical resources needed by the companies. Our findings can indirectly show that these factors contribute towards determining which stakeholders groups are prioritized by the companies studied.

[4] PGO and PSO used a 5-point Likert scale ("never" to "very often"); the rest of the factors used a 6-point Likert scale ("not at all" to "very high").

For example, shareholders control financial resources and have the power to determine companies' value creation strategy (Sarkis et al., 2010); local communities have urgent and legitimate claims regarding any decisions on O&G development operations because they often have to shoulder the environmental and social cost of the development most (Harris and Khare, 2002); governments can create regulatory pressures related to environmental and social protection (Kolk and Pinkse, 2007), and in the case of O&G producing countries can determine companies' ability to access O&G reserves (Wolf, 2009); and the sustainability of suppliers' activities and products can influence the overall performance of a supply chain (Li et al., 2006). For local communities' involvement, the finding is rather in contrast with academic experts' opinion in the Best Worst Method (BWM) study in Chapter 4 that the involvement of local communities is the second least important compared to the other six groups of stakeholders in influencing SSCM practices.

With regard to competition from within the O&G industry (COG) and from the broader energy industry (CEN), the companies are affected by the internal competition more than from the other energy players and sources. This finding is consistent with academic experts' opinion. The effect of the competition is rather low to moderate where the mean score for competition from national O&G companies (NOCs) and international O&G companies (IOCs) is about 2.71 and 2.69 respectively. The competition from alternative energy companies has the lowest mean of 2.09. Similarly, the effect of energy transition (ETR) policies and regulations (REG) on the companies is between low to moderate level. We find companies perceived that the imposition of fiscal, taxation or other measures to promote low carbon/renewable energy during the energy transition has the highest effect on the companies with mean score of 2.76. For the regulatory-related factor, cost related to compliance and remediation has the highest mean score of 3.03, indicating that cost factor could affect companies' operation most, which is consistent with experts' opinion in the BWM analysis as well as Harris and Khare (2002) and McAndrews (2011) studies.

Table 5.7 shows the descriptive analysis conducted for supply chain sustainability goals' measurement items. In the survey, companies are required to rate the extent to which they focus on each goal examined in this study. We find that companies are rather equally focused on strategic (SGO) and functional goals (FGO), which is between moderate to high. Specifically, the focus on safety, health and environmental (SHE) management has the highest mean of 4.03, followed by product responsibility (PRO) with a mean of 3.94. The mean score of companies' focus on the sustainability of supply management (SUP) practices and logistical (LOG) activities is 3.58 and 3.57, respectively.

Table 5.7 – Results of descriptive analysis for sustainability goals' measurement items

	Mean	Std. Deviation
Strategic sustainability goals (SGO)	***3.61***	***0.85***
Provide guidance on company's operations to stake	3.53	0.96
Transparency of sustainability performance report	3.58	1.08
SHE management	4.03	0.97
Energy security	3.31	1.15
Functional sustainability goals (FGO)	***3.70***	***0.82***
Sustainability of supply management practices	3.58	0.88
Sustainability of logistical activities	3.57	0.89
Product responsibility	3.94	0.98

Table 5.8 summarizes the results of the descriptive analysis discussed above, as well as shows the results of correlation analysis of the main variables of this study.

Table 5.8 – Results of descriptive and correlation analysis of main variables

	Mean	SD	PGO	PSO	ECO	STH	COG	CEN	ETR	REG	FGO
PGO	2.61	1.11	1								
PSO	1.91	0.89	0.53***	1							
ECO	3.35	0.91	-0.25*	-0.23*	1						
STH	2.92	0.88	-0.47***	-0.40***	0.54***	1					
COG	2.55	0.98	-0.08	-0.25*	0.20^{+}	0.30**	1				
CEN	2.23	0.85	-0.17	-0.15	0.17^{+}	0.14	0.42***	1			
ETR	2.60	0.97	-0.39***	-0.35**	0.29**	0.43***	0.33**	0.49***	1		
REG	2.86	0.93	-0.28**	-0.46***	0.23*	0.36***	0.38***	0.24*	0.44***	1	
SGO	3.61	0.85	-0.29**	-0.27**	0.60***	0.75**	0.23*	0.05	0.38***	0.25*	1
FGO	3.70	0.82	-0.17	-0.17^{+}	0.36***	0.54***	0.24*	0.06	0.25*	0.16	0.63***

$^{+}p < 0.10$; $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$

For the correlation analysis, it is rather interesting to discover that political stability has negative correlation with SGO and FGO. The results seem to indicate that when companies experience a politically stable business environment, their focus on strategic and functional supply chain sustainability goals will be lower. We initially assumed that a stable environment would provide an ideal condition for companies to implement sustainability initiatives, in line with Urciuoli et al. (2014). The correlation results, however, could also imply that political stability can create a comfortable environment where companies may experience little to no pressure or disruptions in their business activities related to government policies as well as social conflicts and oppositions. Hence, the companies may not be motivated to improve the sustainability of their activities in this environment.

The analysis also revealed that the correlations between independent variables are relatively weak or moderate, based on the rules-of-thumb suggested by Cohen and Holliday (1982), which could indicate low multicollinearity among the variables. This is important for the subsequent multiple regression analysis because high multicollinearity could reduce the variables' predictive power (Hair et al., 2010).

5.5.2 The relationship between external factors and supply chain sustainability goals

Regression analysis was conducted to examine the relationship between the external factors and the supply chain sustainability goals, and to identify the extent to which the factors contribute to the variation in the goals. We used three control variables to test the regression model: company size, revenue and the extent of company involvement along the O&G supply chain. The inclusion of these control variables is similar to a study conducted by Albino et al. (2012). Company size and revenue were measured using ordinal scale. For company involvement along supply chain, respondents were asked to specify the types of O&G operations that they are involved in. We calculate the extent of their involvement based on the total number of operations. The control variables were included to account for the possibility that these factors may influence the extent of companies focus on the goals. We organized the regression models as follows:

a. For the first set, we tested the relationship between the external factors and SGO; followed by the inclusion of the control variables (Table 5.7).
b. Similarly, the second set consists of the regression models between the external factors, the control variables and FGO (Table 5.8).
c. We also analyzed the relationship between the factors and each of the seven sustainability goals that make up SGO and FGO. The remaining two sets of the regression models shown in Table 5.9 and Table 5.10 consist of the results of the analysis without and with the inclusion of the control variables, respectively.

Before proceeding, we examined the variance inflation factor (VIF) of all the models to determine the potential for multicollinearity. The largest VIF score in all of the models is

2.95, well below the maximum level of 10.0 suggested by Mason and Perreault (1991). This further indicates that multicollinearity should not be a problem with our data.

a. The relationship between external factors and strategic sustainability goals

Table 5.7 shows the results of the regression analyses for SGO. The models are highly significant with 61% of the variation in the focus on the strategic goals are explained by the external factors; about 69% to 70% when control variables are included.

Table 5.7 – Results of regression analyses for strategic goals (SGO)

	Strategic supply chain sustainability goals (SGO)				
Variables (n=94)	Model 1	Model 2	Model 3	Model 4	Model 5
Government-induced political stability (PGO)	0.08	0.00	0.02	0.02	0.02
Society-induced political stability (PSO)	0.01	0.08	0.05	0.08	0.09
Economic stability (ECO)	0.29***	0.31***	0.30***	0.35***	0.33***
Stakeholder pressure (STH)	0.59***	0.59***	0.59***	0.57***	0.57***
Competition from within O&G industry (COG)	0.03	0.09	0.08	0.07	0.07
Competition from broader energy industry (CEN)	-0.15+	-0.12	-0.13	-0.14+	-0.14+
Energy transition (ETR)	0.16+	0.06	0.07	0.07	0.08
Regulations (REG)	-0.05	0.05	0.04	0.05	0.06
Control variables					
Size		0.07			0.06
Revenue			0.05		0.00
Extent of activities in SC				0.07	0.07
Regression results					
F	18.84***	21.31***	20.83***	21.68	16.99***
R^2	0.64	0.73	0.73	0.73	0.73
Adjusted R^2	0.61	0.70	0.70	0.70	0.69

+p < 0.10; *p < 0.05; **p < 0.01; ***p < 0.001

Generally, we find that ECO has a highly, statistically significant, relationship with SGO in all models. According to Nuhu et al. (2014), economic stability can influence O&G revenue and companies investment behaviour. Since environmental and social initiatives can be costly (Carter and Rogers, 2008), stable economic conditions allow companies to invest in sustainability initiatives, which would otherwise be prioritized to maintain profit-making activities and infrastructures. We also find that 'stakeholder pressure' (STH) has a highly significant positive relationship with strategic goals. The factor has the largest coefficient in all models indicating that it is the most important factor that can affect supply chain sustainability goals. This is consistent with Seuring and Müller (2008) finding that stakeholder pressure is an important driver of SSCM practices.

Although the relationship is weak, ETR has a significant positive effect on SGO in Model 1, but not significant for FGO (see Table 5.8). The significant relationship between ETR and SGO indicates that when the policy support for alternative energy development is higher, companies will focus more on the strategic goals related to supply chain sustainability. However, this may not be induced by the competition from the broader energy industry, as shown by the significant, albeit weak, negative relationship between CEN and SGO. The advancements in the alternative energy development are relatively slow (Verbruggen et al., 2010). Thus, companies in the O&G industry might have little 'sense of urgency' to compete with the alternatives in terms of sustainable practices. Instead, the increase in focus on strategic sustainability goals may be motivated by the companies seeking to enhance their legitimacy as responsible "corporate citizens", as they transition towards more sustainable energy systems.

Another reason for these findings could be that the companies in the O&G industry themselves might be involved in alternative energy development to benefit from the fiscal and

institutional support given to the energy. This support, for example in the form of tax exemptions and subsidies, provides the incentives for the O&G industry to build their expertise in the alternative energy development. Since the low carbon or renewable energy sources are more sustainable than O&G, companies might be more inclined to be transparent with their involvement in the energy development to offset the negative impact associated with the carbon-intensive O&G development. Involvement in alternative energy development may also require changes in existing management practices, since different energy sources may have different development needs and risks than the O&G. Therefore, the companies in the O&G industry can be expected to increase their focus on improving the strategic aspects of supply chain sustainability, such as through their SHE systems or measures to promote information transparency.

The negative relationship between CEN and SGO could suggest that the companies in the O&G industry do not compete with, for example, alternative energy sources by increasing their focus on environmental and/or social sustainability areas. However, the companies may address the competition by focusing on economic areas. Fouquet (2010) anticipates that the O&G industry would respond to increased competition from alternative energy by making the O&G sources harder to be replaced. For example, the industry can increase O&G supply, thus make them cheaper and quite effectively reduce the feasibility of alternative energy development and its advantages. This could, however, results in trade-off between economic goals with environmental and social goals in competitive energy market as O&G companies may lessen their focus on environmental control to stimulate more O&G production. Unless there are strong financial, moral or personal incentives for companies to develop alternative energy and for consumers to use them, the advantage of the alternative energy over O&G sources is rather weak when O&G prices are low. The suggestion made by Fouquet (2010) and the positive effect of CEN on energy security (ENS), although not statistically significant, could partly support this reasoning (see Tables 5.9 and 5.10).

b. The relationship between external factors and functional sustainability goals

Table 5.8 shows the results of regression analyses between external factors and FGO. All of the models are highly significant where about 26% to 40% of the variations in the focus on functional goals are explained by the external factors and control variables.

Table 5.8 – Results of regression analyses for functional goals (FGO)

	Functional goals (FGO)				
Variables (n=94)	Model 1	Model 2	Model 3	Model 4	Model 5
Government-induced political stability (PGO)	0.08	0.03	0.01	0.03	0.03
Society-induced political stability (PSO)	0.01	0.00	0.06	0.07	0.09
Economic stability (ECO)	0.10	0.19^{+}	0.29^{*}	0.12	0.33^{*}
Stakeholder pressure (STH)	0.51^{***}	0.52^{***}	0.49^{***}	0.52^{***}	0.44^{***}
Competition from within O&G industry (COG)	0.12	0.19^{+}	0.21^{+}	0.18	0.19^{+}
Competition from broader energy industry (CEN)	-0.08	-0.07	-0.07	-0.06	-0.09
Energy transition (ETR)	0.07	0.03	0.05	-0.01	0.07
Regulations (REG)	-0.07	-0.02	0.02	0.03	0.03
Control variables					
Size		-0.24^{*}			-0.06
Revenue			-0.33^{**}		-0.31^{*}
Extent of activities in SC				0.03	0.12
Regression results					
F	5.03^{***}	6.22^{***}	6.90^{***}	5.30^{***}	5.73^{***}
R^2	0.32	0.44	0.47	0.40	0.48
Adjusted R^2	0.26	0.37	0.40	0.32	0.40

$^{+}p < 0.10$; $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$

Unlike strategic goals, the relationship between ECO and FGO is only significant when control variables, size (Model 2) and revenue (Model 3 and Model 5), are included in the analyses. We find that company size and revenue have a significant negative effect on FGO. This suggests that stable economic conditions encourage companies to improve the sustainability of supply chain functional areas, but this can be expected more among companies that are smaller or with lower revenue.

Existing studies suggest that larger companies are more likely to adopt sustainable practices (Pagell et al., 2004, Zhu et al., 2008). However, small companies can benefit from their strategic characteristics such as shorter lines of communication, flexibility of managing external relationships and entrepreneurial orientation (Aragón-Correa et al., 2008). It may be easier for smaller companies to manage their supply chains due to, for example, fewer numbers of suppliers or products that allow them greater flexibility to integrate sustainable practices in the management of their chains. The advantages afforded by their size are especially important in a competitive market. This is clearly shown in Model 2 where competition within the O&G industry affects FGO positively, but smaller companies are more likely to increase their focus on the goals.

Seuring and Müller (2008) note that the cost of green initiatives can hinder the adoption of SSCM practices. A decline in revenue may force companies to implement selective investment measures to reduce operating costs and ensure financial efficiency. This can be challenging when the companies are also pressured to improve the sustainability of their activities. A strategy that focuses on streamlining and creating synergies with supply chain partners could help companies address this problem and minimize supply chain risks (Jüttner and Maklan, 2011; Olson, 2010). In addition, a study by Yusuf et al. (2013) reveals that companies in the UK O&G industry are able to reduce production cost, for example, through initiatives that encourage business meetings via teleconference, use of energy saving devices and recycling programs.

We find rather interesting results regarding the relationship between types of competitions (COG and CEN) and strategic and functional goals. Generally, COG has significant positive effect on the FGO (when control variables are included), but no effect on the SGO (see Model 2, 3 and 5 of Table 8). As discussed earlier, the opposite is found for the effect of competition from CEN on the goals – the competition from the broader energy industry has no significant effect on FGO, but significant negative effect on SGO. Although the relationship is rather weak, it helps us in understanding the effects of competition from different actors and sources of energy on the goals.

It appears that a higher focus on improving the sustainability of supply chain functions can give companies the advantage needed to address competition within the O&G industry. Increased competition between NOCs and IOCs caused the IOCs to develop O&G unconventional sources such as oil sands and shale gas which are outside of NOCs control (Kjärstad and Johnsson, 2009, Mitchell and Mitchell, 2014). Major challenges in the management of the oil and gas supply chain are associated with the inflexibility of its logistical network, high transportation and inventory costs due to the distances between supply and demand centres, as well as between supply chain partners, and high variability of transportation time (Hussain et al., 2006). The development of unconventional O&G increases the challenge as it requires greater control in the supply chain due to the higher environmental and financial risks involved (Farrell and Brandt, 2006). Therefore, companies that perform well in these aspects will have the advantage over competitors, especially when they are able to incorporate sustainability aspects in their supply chain.

c. The relationship between external factors and each supply chain sustainability goal

The results of the regression analyses for each sustainability goal without and with control variables are shown in Table 5.9 and Table 5.10, respectively. Among the goals, we find that the external factors are able to explain the variances in 'transparency of sustainability performance reporting' (TRA) and 'providing guidance to stakeholders with regard to company operations' (GUI) most; the explained variances are 53% and 48% respectively. The inclusion of the control variables increased the score of variance explained, where GUI has the highest score of 63%.

Table 5.9 – Results of regression analyses of each goal

	Focus on supply chain sustainability						
Variables (n=94)	SHE	GUI	TRA	ENS	SUP	LOG	PRO
Government-induced political stability (PGO)	0.00	0.15	0.09	0.04	0.06	0.11	0.07
Society-induced political stability (PSO)	0.15	-0.12	0.00	-0.01	0.01	0.03	0.00
Economic stability (ECO)	0.23^{*}	0.37^{***}	0.28^{***}	0.10	0.16	0.05	0.05
Stakeholder pressure (STH)	0.28^{*}	0.39^{***}	0.55^{***}	0.68^{***}	0.49^{***}	0.58^{***}	0.31^{*}
Competition from within O&G industry (COG)	0.10	0.08	0.06	-0.10	0.18^{+}	0.04	0.10
Competition from broader energy industry (CEN)	-0.26^{*}	-0.13	-0.13	0.01	-0.08	-0.07	-0.08
Energy transition (ETR)	0.19	0.15	0.15	0.06	0.04	0.05	0.10
Regulations (REG)	0.13	-0.02	-0.06	-0.18^{+}	-0.12	-0.04	-0.03
Regression results							
F	4.85^{***}	11.85^{***}	14.07^{***}	9.39^{***}	6.20^{***}	5.07^{***}	1.77^{+}
R^2	0.31	0.53	0.57	0.47	0.37	0.32	0.14
Adjusted R^2	0.25	0.48	0.53	0.42	0.31	0.26	0.06

$^{+}p < 0.10$; $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$

Generally, STH has the most significant relationships with all goals. We find that ECO has a significant positive relationship with three strategic goals SHE, GUI and TRA, but no relationship with ENS. REG, on the other hand, has a significant negative relationship with ENS.

Companies in the O&G industry have to deal with considerable regulatory and compliance risks (Wagner and Armstrong, 2010), where the cost of compliance varies widely and especially financially draining for smaller companies (Harris and Khare, 2002). The more regulated the O&G industry is, the greater the risks that companies have to consider and the costs needed to satisfy the regulatory requirements. Changes in the requirements or introduction of new policies could affect their ability to operate smoothly, for example due to the need to stop production activities until regulation requirements are met, which could threaten their focus on energy security. In addition, companies might be discouraged to pursue innovation in energy technologies to improve energy security due to the increase in the requirements. This reasoning can be supported by the findings of Grekova et al. (2014) who observe that regulatory pressure may hamper the development of novel environmental technologies.

CEN also has significant negative relationship with SHE management. The O&G production is highly cost-intensive and SHE protection measures also require large investment. This could result in a trade-off between economic goals, environmental and social goals in competitive energy market, resulting in less focus on SHE management. Therefore, the competition could be based more on the commercial area rather than the sustainability area.

Table 5.10 shows that ECO has a weak positive relationship with companies' focus on 'sustainability of logistical activities' (LOG) goal when control variables are included in the model. We find that PSO has significant positive relationship with the focus on SHE – the only significant relationship related to political stability factor among all of the models in this study. The analysis shows that the companies' focus on SHE management goal is higher when they experience less disruption from societal sources such as unrest or oppositions to their operations. This is rather in contrast with the negative correlation observed between PSO with SGO and FGO discussed earlier, see Table 5.6. The positive relationship between PSO and SHE, when the control variables are included in the model, could indicate that companies' characteristics could play a role in how they address the political pressure from societal sources. However, we are not able to identify which of the control variable can affect the relationship most because none of them is statistically significant.

Table 5.10 – Results of regression analyses of each goal with control variables

	Focus on supply chain sustainability						
Variables (n=94)	SHE	GUI	TRA	ENS	SUP	LOG	PRO
Government-induced political stability (PGO)	-0.09	0.06	0.05	0.04	0.02	0.04	0.01
Society-induced political stability (PSO)	0.27*	-0.10	0.07	0.07	0.11	0.05	0.07
Economic stability (ECO)	0.15	0.43***	0.33**	0.18	0.40***	0.26^{+}	0.24
Stakeholder pressure (STH)	0.30*	0.40***	0.51***	0.62***	0.43***	0.53***	0.27^{+}
Competition from within O&G industry (COG)	0.12	0.14	0.07	-0.07	0.26**	0.12	0.14
Competition from broader energy industry (CEN)	-0.27*	-0.11	-0.10	0.00	-0.06	-0.07	-0.12
Energy transition (ETR)	0.05	0.04	0.09	0.06	0.03	0.06	0.10
Regulations (REG)	0.24*	0.09	0.05	-0.14	-0.03	0.00	0.10
Control variables							
Size	0.19	0.05	0.04	-0.05	-0.03	-0.12	0.01
Revenue	0.05	-0.06	-0.02	0.01	-0.30*	-0.23	-0.29
Extent of activities in SC	0.03	-0.03	0.06	0.25	0.16	0.06	0.11
Regression results							
F	4.55***	12.98***	10.32***	6.52***	7.50***	5.13***	2.09*
R^2	0.42	0.68	0.63	0.51	0.55	0.45	0.25
Adjusted R^2	0.33	0.63	0.57	0.43	0.48	0.37	0.13

$^{+}p < 0.10$; $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$

Similarly, increase in REG relates to higher focus on SHE management. According to Wagner and Armstrong (2010), leading companies conduct environmental, social and health impact assessments (ESHIA) which is considered a minimum acceptable standard of good practice for environmental and social risk management to address the regulatory pressure, and to minimize the risk of non-compliance for all major new projects. Zhu et al. (2007) observed a somewhat similar finding; higher regulatory pressures by government lead to greater level of GSCM practices among chemical/petroleum companies.

ECO and COG have a highly significant positive relationship with sustainability of 'supply management practices' (SUP) when all control variables are included in the model. This indicates that companies would focus more on improving SUP practices in a competitive O&G industry environment when the economic condition is stable. However, the focus can be expected to be higher among companies with lower revenue. This could be attributed to the greater need for these companies to have better SUP, such as more efficient and flexible sourcing practices and contract management that could help in cost and waste reduction. For example, Zhu et al. (2007b) find that cooperation with suppliers in eco-design programs can

improve supply chain efficiency and reduce costs. Tesfay (2014) suggests similar results can be obtained when O&G companies work closely with service providers to improve environmental performance of logistics activities.

The O&G product mix is static where the products are also traded among companies in the industry. Therefore, there is very little product variation that could differentiate them. Furthermore, companies that control O&G reserves will have more power in selecting their alliance (Edwards et al., 2010). A more sustainable SUP could help a company gain competitive advantage in the market, thus provide better opportunities for it to be awarded a contract in an O&G development project.

The needs for greater focus on SUP in the O&G industry may also relate to the implementation of local content strategy. O&G companies are often required by governments to incorporate local materials and suppliers in their activities as part of O&G project licensing agreement. Local suppliers might lack the necessary capabilities to meet, for example, high environmental standards required in the O&G industry, which could be detrimental to supply chain sustainability performance (Hall et al., 2012). Therefore, more focus on SUP is necessary in this condition. Increased focus on sustainable supply chain practices will help companies to differentiate themselves (Beske and Seuring, 2014). This can help companies to secure their competitive position in the industry, which is especially important in a time when they are facing greater pressure to operate sustainably.

5.6 Discussion and conclusion

Overall, the regression analyses show that stakeholder pressure, measured by stakeholder involvement, has the strongest relationship with supply chain sustainability goals. Even though stakeholder pressure is the most important factor that could affect the goals, the involvement of the stakeholders at strategic level in helping the companies studied to address sustainability issues is, in fact, relatively moderate.

It is rather difficult for companies to involve all stakeholder groups and to consider their claims that are in conflict with companies' interest and resource availability. In order to address this problem, companies could employ proactive stakeholder engagement strategies by identifying the relevant stakeholder groups that could affect or be affected by their supply chain decisions and operations early on in a project. This process would allow the companies to identify the stakeholders' expectations and concerns, thus determine appropriate actions that can be taken to address them. It would also help the companies to develop an SSCM strategy that incorporate these aspects, thus minimizing the potential risks from grievances resulting from inefficient handling of stakeholder relations and expectations.

Government authorities such as in Alberta, Canada, require O&G companies operating in the region to notify the public and address their concerns before a project is authorized. The requirement has resulted in better stakeholder engagement and due diligence since costly delays can occur if the requirement is not handled properly (Harris and Khare, 2002). This institutional pressure, which is also from an important stakeholder group in O&G development, could help companies to determine the appropriate or expected level of engagement with various stakeholders that can affect or be affected by their operations.

We find an interesting observation with regard to the positive effect of energy transition and the negative effect of competition within the broader energy industry on strategic supply chain sustainability goals. It appears that increased focus on strategic goals may have little to do with competition from other energy players and sources, as companies transition themselves towards low carbon energy systems. Companies might benefit from policy support given to alternative energy development by starting their own project to build their expertise

in the area. They could also develop partnerships or acquired companies involved in alternative energy development to provide a stronger platform for their involvement. For example, Repsol acquired a company that promotes alternative energy projects and Total acquired a start-up company that develops purified silicon for solar power (Repsol, 2011, Total, 2011). Involvement in alternative energy development may require changes in their SHE management systems. But increased focus on strategic goals such as transparency could be motivated by the need to enhance public perception and their legitimacy as responsible corporate citizens (Carter and Rogers, 2008). Our analyses do not produce significant relationship between energy transition and individual strategic goals. More in depth research can be conducted to examine this relationship further.

We also think that companies in the O&G industry might compete with other energy players and sources in commercial areas, which are based on supply and price, rather than on environmental or social sustainability. It seems that a trade-off between economic, environmental and social sustainability goals might occur in this relationship, as environmental control would probably be reduced to accommodate and stimulate more O&G production. Fouquet (2010) suggests that the O&G industry will become more competitive and harder to be replaced when they face greater pressure from alternative energy during the transition. Although the share of alternative energy in the future energy mix will continue to increase, its rate of diffusion is slow. Therefore, the potential of alternative energy is limited until considerable progress is achieved in its technology (Fouquet, 2010, Markevicius et al., 2010). In addition, the technological lock-ins of infrastructure based on the O&G sources such as in transportation might give little sense of urgency to the companies to compete with alternative energy.

Still, the O&G industry cannot afford to ignore the competition for long. Continuous monitoring of the progress of the alternative energy is necessary. In addition, it is important for the O&G industry to play a more prominent role in promoting sustainable energy development by deploying its innovation and technological expertise, as well as financial capabilities. Alternative energy sources like biomass could benefit from the technological learning curve afforded by the experience and sophistication of O&G development – in addition to the advantages from the economies of its integration into the existing energy infrastructure (Szklo and Schaeffer, 2006). Through the integration of alternative low carbon energy in their supply bases, companies in the O&G industry can improve the sustainability of their supply chains. It will also help the companies to transition themselves so as to remain relevant in a low carbon energy future. Nevertheless, it important to note that companies' operating context such as location and ownership could determine their involvement in alternative energy development. For example, companies operating in countries with favourable government policy and incentives may be encouraged to invest in low carbon energy project (Pinkse and van den Buuse, 2012).

The findings regarding competition and energy transition on supply chain sustainability goals can especially be relevant to managers and policy makers with regard to the role of O&G industry and governments during energy transition. Although O&G might remain the major energy source for decades to come, over time, the view that O&G and its alternatives are competing must change into one of complementarity. Stronger incentives to promote collaboration between energy players are necessary to facilitate the development of more sustainable energy solutions and technologies. Currently, our finding is that the effect of energy transition and competition from the broader energy industry on supply chain sustainability goals is relatively weak. However, energy transition is an important issue in sustainable energy development, which could affect future survival of the O&G industry. Therefore, further research should be conducted to better understand the relationship between

these factors in order to exploit possible synergies between alternatives and to spur the transition to a more sustainable energy systems.

Another opportunity for additional research concerns the distinction between upstream and downstream companies. The effect of the external factors, stakeholder pressure for example, may be different upstream where companies have to deal more with risks related to ownership and access to reserves compared to downstream companies, which deal with supply and consumer related risks. Our survey did not allow us to reach separate conclusions for these groups, partly due to the involvement of companies in overlapping business sectors. A sampling strategy that would distinguish these business sectors could help in determining the differences. In addition, longitudinal or case studies may be conducted to gain better understanding on how the factors can affect supply chain sustainability goals and how companies adapt to the dynamics of their business environment. Finally, further study could also be conducted to explore the effects of different stakeholder groups, for example commercial and non-commercial, as well as internal motivations to compete on supply chain sustainability goals.

Through this study we are able to understand the relationship between external business environment factors and supply chain sustainability goals of companies in the O&G industry. The external factors are often beyond companies' control due to their complex interrelationships, which creates sustainability pressure that can influence their relevancy. In order to overcome the pressure, they must develop supply chain management strategies that are able to exploit their existing internal resources and capabilities or acquire new ones. Formulation of internally consistent supply chain sustainability goals will facilitate the alignment between the external pressure and internal capabilities. It could also create synergies among different departments and supply chain functional areas towards better SSCM practices to achieve companies' sustainability goals.

In the next chapter, we will focus our discussion on the influence of internal organizational factors, specifically commitment to sustainability and management preparedness, on the adoption of sustainable supply chain strategies in the O&G industry.

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6. Commitment to and Preparedness for Sustainable Supply Chain Management Implementation

This chapter is based on: Wan Ahmad, W.N.K., Rezaei, J., Tavasszy, L.A. and De Brito, M. P. (2016), "Commitment to and preparedness for sustainable supply chain management in the oil and gas industry", Journal of Environmental Management, Vol. 180, pp. 202-213.

6.1 Introduction

Our review of sustainable supply chain management (SSCM) literature revealed that there is a lack of understanding about the internal organizational factors that can influence the implementation of SSCM practices in the oil and gas (O&G) industry. Although the broader SSCM studies have identified internal factors such as top management leadership, culture and risk management as important drivers for sustainable practices, there is little empirical evidence to support such relationships in the O&G supply chain context. In addition, there is no study that examines how SSCM strategy of different supply chain functional areas can be affected by the factors. This research gap must be addressed because it will help us to identify internal resources or capabilities that must be employed to address the challenges involved in SSCM implementation in the O&G industry. It will also help us to understand how companies can create synergies between different capabilities and supply chain functional areas for better SSCM implementation.

In order to address this gap, this chapter focuses on understanding the relationship between internal factors, i.e. companies' commitment to and preparedness for sustainable practices, with their supply chain sustainability strategies related to the management of four supply chain functions, namely supplier management, production management, product stewardship and logistics management. The four functions are chosen because they represent the main areas in supply chain management that are involved in acquisition of new or used materials/resources, used to produce and deliver products as well as services that could satisfy customer requirements.

To achieve this aim, we formulated the research questions for this chapter as follows:

> *What are the relationships between internal factors (commitment to sustainability and management preparedness) and sustainable supply chain strategies of companies in the O&G industry?*

In order to answer this research question, we perform an exploratory factor analysis on data gathered through the industry survey discussed in Chapter 5. We then test the relationships between the factors using multiple regression analysis.

Generally, this chapter is organized as follows. Section 6.2 reviews existing literature related to the internal factors that could influence the O&G industry's SSCM practices. Section 6.3 describes the methodology used in this study. It is followed by Section 6.4 that discusses the results of data analysis. Section 6.5 concludes this study by highlighting our main findings, the implications to practice and opportunities for further research.

6.2 Internal factors of supply chain sustainability: literature review

We have discussed the literature related to the internal factors that can influence the implementation of SSCM practices in Chapter 2. For ease of reference, we include the discussion again in this chapter.

According to Seuring and Müller (2008b), companies respond with SSCM strategies to external pressures for more sustainable practices in supply chain activities, such as pressure from regulatory requirements and stakeholder demand. The concept of SSCM presumes that economic, environmental and social goals of individual companies and their supply chains can be achieved through particular managerial behaviour or decisions, that facilitate strategic and transparent integration of key business processes and cooperation among supply chain members (Carter and Rogers, 2008, Seuring and Müller, 2008b, Pagell and Wu, 2009). The review of the SSCM literature indicates that the decisions and behaviour comprises organizational factors related to: commitment to sustainability, management preparedness for sustainable practices, and supply chain sustainability strategy. The relationship between these factors can be illustrated as in Figure 6.1 – this basically mirrors the relationship proposed in the conceptual framework of this thesis (see Figure 2.3).

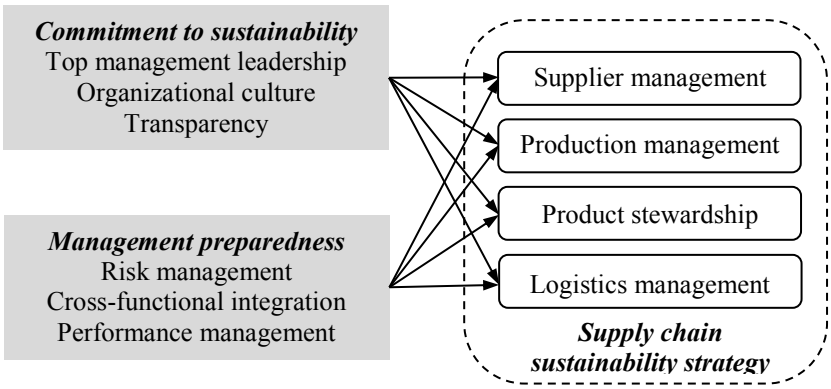

Figure 6.1 – The relationship between internal factors and sustainability strategy of different supply chain functional areas

Companies' commitment towards sustainable practices can be demonstrated through top management leadership, development of organizational culture that promotes sustainable

behaviour, and transparency of business conduct. Studies have shown that *top management leadership* are important to the implementation of sustainable supply chain practices (Zhu et al., 2005, Walker and Jones, 2012, Harms et al., 2013). Pagell and Wu (2009) found that top management of exemplars in sustainable practices exhibit a proactive stance towards sustainability. For example, proactive approaches to supplier management could enable companies to become first movers in developing sustainable products and supply chain (Seuring and Müller, 2008a, Paulraj, 2011).

Similarly, a study by Thurner and Proskuryakova (2014) reveals that management initiatives are one of the main drivers for green production practices among Russian O&G companies. Management support is also crucial to mutual learning processes in organizations because communication of a clear SSCM strategy by managers will encourage employees to show greater dedication to its achievement (Wittstruck and Teuteberg, 2012, Wu and Pagell, 2011). This could, in turn, foster organizational culture that facilitates an effective implementation of SSCM strategy and initiatives.

Walker and Jones (2012) found that *organizational culture* is one of the internal enablers of SSCM practices. Companies that have better sustainability performance are ingrained with a set of values that define their sustainability principles, shape business models and guide decision making (Pagell and Wu, 2009). Sustainability culture encourages a company to adopt socially responsible supply chain practices through, for example, supply chain monitoring (Frankel and Mollenkopf, 2015). These findings are in line with Carter and Rogers (2008) suggestion that organizational culture is one of the facets that support sustainable supply chain practices, apart from strategy, risk management and transparency.

Transparency in SSCM entails that companies report to and actively engage with stakeholders to improve supply chain performance, which can be facilitated by vertical integration across supply chain and horizontal integration across networks (Carter and Rogers, 2008). Pagell and Wu (2009) show that transparency and/or traceability is a novel form of existing information sharing practice in SSCM. They point out that this practice is initially done by demanding suppliers to disclose, for example, the materials used in the production process and its by-products to minimize risks to business, environment and consumers. This practice leads to the exchange of knowledge related to business processes, which can consequently be used to improve supply chain performance in terms of, for example, sourcing practices and risk management (Pagell and Wu, 2009).

In this study, we consider risk management, cross-functional integration and performance management as internal capabilities that can indicate companies' preparedness towards SSCM practices. The implementation of GSCM practices is found to result in better *risk management* related to brand image and quality, thus supporting the notion that sustainable practices can enhance a company's reputation (Campbell, 2007). The economic and environmental risks of supply chain activities can also be addressed through closed-loop production and logistics processes (Wittstruck and Teuteberg, 2012). Although the cost of green practices could hinder its adoption (Seuring and Müller, 2008b, Campbell, 2007), close cooperation with supply chain partners could facilitate more effective risk assessment practices that is beneficial to every company in the chain (Chang et al., 2013, Beske and Seuring, 2014). This is especially helpful to a company that might be constrained by its lack of resources to develop more comprehensive risk management measures. SSCM, therefore, should enable collaboration between supply chain partners in developing supply chain solutions that can collectively improve their capabilities and competitiveness (Gold et al., 2010).

The lack of coordination and communication in supply chains could lead to ineffective implementation of SSCM strategies (Seuring and Müller, 2008b, Beske and Seuring, 2014). Strategic collaboration with suppliers enables companies to develop supply chain capabilities and knowledge that can be used in green product and process design as well as waste and cost

reduction (Paulraj, 2011). Zhu et al. (2005) find that companies may realize the importance of *cross-functional integration* in sustainable practices as they strive to incorporate environmental management in supply chain and product design. However, it appears that some companies may neglect to consider corporate functions that are not directly related to SSCM practices such as marketing and R&D, which then hinders the implementation of more encompassing cross-functional collaboration (Harms et al., 2013). This could consequently affect the overall supply chain performance negatively.

Effective *performance management* of SSCM strategy implementation can help companies to identify the business impacts and improvement opportunities of the implementation. This could facilitate more informed decision making processes and continuous improvement of their SSCM practices. While there are tools that can be used to measure sustainability performance, such as life cycle analysis (LCA), the application of these tools could be limited due to the absence of formal metrics that guide measurement, and the lack of understanding of sustainability in organizations (Pagell and Wu, 2009, Zhu et al., 2007). The lack of formal metrics makes it difficult to map supply chain structure, to measure system performance and to identify which sustainability initiatives lead to improvement in the performance (Zhu et al., 2007, Chan and Qi, 2003). Seuring and Müller (2008a) find that supply chain performance can be improved more effectively when suppliers are clear about the sustainability requirements that must be fulfilled. These requirements, in turn, can be identified more efficiently if companies are able to monitor and control SSCM implementation through systematic performance management of their supply chain activities.

In summary, SSCM studies that are specific to the O&G supply chain context are necessary since the industry is challenged by sustainability pressures that may be different than other industries. It is important to have a greater understanding of the internal factors that could affect the strategies that the O&G industry employs to address these pressures and improve its supply chain management practices.

We now turn to the empirical analysis of this framework, where our aim is to study the strength of the relationships proposed in Figure 6.1. In the following sections, we introduce the approach taken in our empirical analysis, describe the outcomes and provide an interpretation of the results.

6.3 Methodology

This section describes the methodology that is used to understand the relationship between internal factors and supply chain sustainability strategy adopted by companies in the O&G industry.

6.3.1 Questionnaire development

As mentioned earlier in Chapter 5, we developed a questionnaire based on the literature review as well as input from academics and industrial experts to collect data from companies that operate in upstream and/or downstream segment of the O&G supply chains. The questionnaire was pre-tested with three experts from O&G companies through interviews and emails, before being administered to the survey sample.

Overall, the questionnaire contains five sections, three of which are the focus of this paper. The three sections comprise items that measure:

a. Commitment to sustainability – top management leadership, organizational culture and transparency (three questions, 21 measurement items);

b. Management preparedness in implementing sustainable practices – risk management, cross-functional integration and performance management (three questions, 20 measurement items); and
c. Sustainable supply chain strategies – supplier management, production management, product stewardship and logistics management (six questions, 53 measurement items).

Three questions were posed to measure supplier management strategy, specifically in terms of supplier selection, supplier development and local supplier development practices. All questions were answered using a five-point Likert scale, i.e. 1 = very low, 2 = low, 3 = moderate, 4 = high, 5 = very high; only supplier selection used a different five-point Likert scale, i.e. 1 = not important, 2 = less important, 3 = important, 4 = very important, 5 = extremely important. Please refer to Appendix III for the full questionnaire.

6.3.2 Data collection

The data collection process and sampling characteristics of this study are discussed in Chapter 5; therefore, it will not be reported again in this section. An important detail that must be clarified here is regarding the number of valid responses that can be used to analyze the relationship between internal factors and supply chain sustainability strategy.

In Chapter 5 we explained that 94 out of 107 returned questionnaires are usable in analyzing the relationship between external factors and supply chain sustainability goals. However, among the 94 responses, only 81 can be further used to analyze the remaining factors proposed in our conceptual framework. We employed this approach in our data analysis to maximize the number of cases that can be used to test the relationship proposed.

6.3.3 Data preparation

In order to prepare the data gathered for further analysis, we first checked the data for potential of non-response bias. We used the method suggested by Armstrong and Overton (1977), where we compare the responses of the first wave of the online and mail survey with the second wave of the responses to check for the bias. In this approach, the first two thirds of the responses are considered as the first wave, while the remaining responses are the second wave. We used a *t*-test to analyze the differences between the two waves using company characteristics as indicators. The results are as shown in Table 6.1, where the *t*-test indicates there are no significant mean differences between the responses of the two waves. Therefore, we can assume that non-response bias should not be an issue in our survey.

Table 6.1 – *t*-test results for non-response bias

	t-Test for Equality of Means		
	t	df	Sig. (2-tailed)
Size	-1.26	78	0.21
Revenue	-1.32	77	0.19
Number of countries a company operates in	1.15	78	0.25
Extent of activities in O&G supply chain	-0.29	79	0.77

Exploratory factor analysis was conducted to derive groupings and reduce data in the items used to measure internal factors and supply chain sustainability strategy. The factors were extracted using the principal component method, followed by varimax rotation. In order to determine the factors that can be retained for analysis, we selected the factors with eigenvalues that are greater than 1 since each factor must account for the variance of at least a single variable (Hair et al., 2010). In addition, we also used factor loadings greater than ±0.50 as threshold in the selection criteria due to its practical significance as suggested by Hair et al. (2010).

Table 6.2 and Table 6.3 show the results of the factor analysis for items measuring commitment to sustainability and management preparedness; the tables include the Cronbach's alpha value of each factor. We conducted two separate factor analyses for the items, since they measure different concepts.

Table 6.2 – The results of exploratory factor analysis for commitment to sustainability

Factor	Measurement items	Factor loading	Cronbach's alpha
Top management leadership (LEA)	Generate consensus on future direction for sustainable development	0.87	0.90
	Key role in creating sustainability values	0.81	
	Encourage long-term strategic thinking in sustainable development	0.79	
	Provide resources for employees to learn sustainability related knowledge	0.74	
Organizational culture (CUL)	Team oriented	0.78	0.83
	Proactive	0.76	
	Flexible	0.74	
	Open	0.67	
	Innovative	0.63	
	Opportunistic	0.59	
	Competitive	0.56	
	Risk taker	0.51	
Transparency (TRA)	Performance disclosure based on sustainability guidelines	0.84	0.89
	Prompt response to any sustainability-related inquiry/report	0.80	
	Regular updates of sustainability performance on the corporate website	0.73	
	Invite stakeholders for company visits	0.72	
	Provide guidance & clarification on company's operations to stakeholders	0.70	
	Ensure that sustainability performance measurement system is continually improved	0.64	

For the commitment to sustainability items, the factor analysis reveals the presence of three factors as proposed in our framework. We removed three items that were used to measure organizational culture due to factor loadings less than 0.50. One item that was predicted as an indicator for top management leadership was found to be grouped in the transparency factor, i.e. the last item listed under transparency, which we retained for further analysis.

As for the management preparedness items, four factors were derived from the analysis as shown in Table 6.3. We found that risk management is composed of two factors that can be categorized as macro-environment risks and operational risks. We retained both of the factors for further analysis because it could help us to understand company responses to different types of risks in the supply chain. The three factors of commitment to sustainability and the four management preparedness factors explain, respectively, 62.6% and 71.9% of the variance in their measurement items. This is in line with Hair et al. (2010) suggestion that the number of factors retained should have explained variance of at least 60%.

Table 6.3 – The results of exploratory factor analysis for management preparedness

Factor	Measurement items	Factor loading	Cronbach's alpha
Management of macro-environment risks (RMM)	Political condition	0.83	0.72
	Economic condition	0.81	
Management of operational risks (RMO	SHE risks of products	0.78	0.86
	Preparedness for emergency situation	0.76	
	Relationship with stakeholders	0.73	
	Law and regulations related to SHE protection	0.73	
	SHE risks of logistical activities	0.69	
	Ethical business conduct of suppliers	0.68	
Cross-functional integration (CFI)	Suppliers	0.85	0.92
	SHE impact of logistical activities	0.80	
	Stakeholders	0.80	
	SHE impact of products	0.74	
	SHE impact of operations	0.73	
	Resource efficiency	0.71	
Performance management PEM)	Review company-wide sustainability performance management systems regularly	0.88	0.92
	Use formal metrics to measure sustainability performance	0.86	
	Link sustainability to measurement and reward systems	0.85	
	Use formal metrics to quantify sustainability benefits	0.85	
	Use information systems to manage sustainability-related data	0.84	

We also conducted separate factor analyses for items measuring sustainable supply chain strategies due to the differences in their concepts. Table 6.4 shows the analysis results for supplier selection.

Table 6.4 – The results of exploratory factor analysis for supplier selection strategy

Factor	Measurement items	Factor loading	Cronbach's alpha
Business conduct	Ability to meet company's sustainability requirements	0.86	0.78
	Supplier's environmental certification	0.82	
	Code of business conduct of supplier	0.68	
	Contract compliance	0.55	
Cost/quality	Relative price/cost	0.77	0.69
	Supplier's cost-reduction capability	0.75	
	Quality of service/product	0.69	
	Technical capability	0.53	
Reliability	Supplier firm reputation	0.75	0.60
	Supplier financial conditions (i.e. assets and liabilities)	0.65	
	Likelihood of long term relationship	0.63	
Proximity/size	Geographical location	0.87	0.62
	Size of supplier firm	0.69	

As mentioned earlier, three questions were used to measure supplier management strategy (SUP), namely supplier selection, supplier development and local supplier development. The factor analysis for supplier selection items was done separately from the rest of supplier-related items. The analysis indicates the presence of four supplier selection factors that we labelled as selection based on supplier business conduct, cost/quality, reliability and proximity/size. Three items were removed due to factors loadings below 0.50. The four supplier selection factors account for approximately 62.4% of explained variance.

For the items measuring supplier development, all items were analyzed together to test if there are distinct strategies for different group of suppliers. The results of the analysis shown in Table 6.5 indicate the presence of two factors, as we predicted. The first group of items are related to more general supplier development strategy. The second group of items, on the other hand, are specific to local supplier development strategy that can be used to enhance the involvement of local businesses and products in supply chain. The total variance explained by the supplier development factors is 71.9%.

Table 6.5 – The results of exploratory factor analysis for supplier development strategy

Factor	Measurement items	Factor loading	Cronbach's alpha
Supplier development	Run workshops/seminar to educate suppliers	0.88	0.90
	Bring together suppliers in the same industry to share their know-how and problems	0.87	
	Go into suppliers' organizations to help them improve sustainability performance	0.85	
	Guide suppliers to have their own environmental & social sustainability programs	0.78	
Local supplier development	Direct relationship with local suppliers	0.85	0.66
	Requires foreign suppliers to cooperate with local businesses	0.69	
	Facilitate access to credit and financing assistance/options	0.57	

We also conducted one factor analysis for the items used to measure production management and product stewardship as shown in Table 6.6. This is to ascertain that we are indeed measuring two different factors, which is important because of their interrelationship. We found two separate factors as proposed in the framework, where two items were deleted due to cross-loadings. The two factors explained 63% of variance in their measurement items.

Table 6.6 – The results of exploratory factor analysis for production management (PRO) and product stewardship (PSW) strategy

Factor	Measurement items	Factor loading	Cronbach's alpha
Production management (PRO)	Recycle hazardous waste	0.85	0.83
	Recycle waste water	0.80	
	Work with suppliers in waste minimization	0.78	
	Train employees on occupational health & safety protection	0.72	
Product stewardship (PSW)	Tailor product safety warning to comply with current and emerging regulations	0.83	0.86
	Involve potential suppliers during new product development	0.77	
	Assess compliance with product safety legislation both where the products are made and in their intended markets	0.76	
	Undertake life-cycle assessment during product design stage	0.75	
	Use environment-friendly alternative components/ materials	0.72	
	Design product packaging to be safe & ecologically sound	0.65	

For the logistics management items, the results of factor analysis shown in Table 6.7 indicate that they contain two factors. We categorized the factors as strategies related to green logistics and transport safety. We removed three of the initial items because their factor

loadings are significant in both of the factors. Approximately 63.6% of variance in the items can be explained by the two factors.

Table 6.7 – The results of exploratory factor analysis for logistics management (LOG) strategy

Factor	Measurement items	Factor loading	Cronbach's alpha
Green logistics	Recycle/ reuse container	0.76	0.89
	Use of energy efficient vehicles	0.74	
	Use of recyclable packaging/pallet systems	0.74	
	Invest in vehicles designed to reduce environmental impacts	0.72	
	Require suppliers to take back their packaging/pallet systems	0.68	
	Preference for environmental-friendly transport mode	0.64	
	Collect packaging/pallet systems from customers	0.63	
	Use of multi-modal transport to reduce environmental impact	0.61	
Transport safety	Transport safety training for drivers	0.85	0.90
	Safety & health risks of transport mode	0.83	
	Safety & health of drivers (e.g. driving and resting time etc.)	0.82	
	Inspection & maintenance of vehicles	0.80	

As shown in Table 6.2 to Table 6.7, the Cronbach's alpha values for all factors are well above 0.70, except for items measuring three of the supplier selection factors and local supplier development where their scores are above 0.60. Hair et al. (2010) and Flynn et al. (1990) suggest that a threshold of 0.70 should be used to ensure construct's internal consistency. A value lower than 0.60, however, can be used in exploratory research (Hair et al., 2010).

For the subsequent analysis of this chapter, we will use the composite score of supplier management and logistics management to focus our discussions on the four supply chain functions. Nevertheless, we will also discuss the sustainability strategies of each function in relation to the individual factor identified through the factor analysis.

Before further analysis, we checked the extracted factors for the potential of common method bias using Harman's single-factor test (Podsakoff and Organ, 1986). Two indicators can be used to check for the bias. First, as mentioned earlier, all factors with eigenvalues greater than 1 are retained for further analysis. Second, no single factor retained for each of the construct of this study accounts for the majority of their variance. Specifically, the explained variances of the first extracted factors in each factor analysis are as follows: commitment to sustainability (21.46%), management preparedness (21.33%), supplier selection (18.23%), supplier development (47.15%), production management and product stewardship (35.32%) and logistics management (34.42). Therefore, we can assume that common method bias is not an issue in our study.

We also test the normality of our data. The Kolmogorov-Smirnov test for the main variables, apart from product stewardship, show that their *K-S* values are not significant (> 0.05). However, the skewness and kurtosis values of product stewardship are -0.27 and -0.13, well below the critical values of ±1.96 (at 0.05 significance level) suggested by Hair et al. (2010). Thus, we assumed that our data are normally distributed. We will continue the discussion of the results of our data analysis in the next section.

6.4 Analysis and discussion

This section describes the internal organizational environment in which our sample companies operate, specifically in terms of their commitment to sustainability and management preparedness. We will also explain the sustainable supply chain strategies adopted by the companies. Both of these are based on the descriptive analysis of the factors. In order to understand the relationship between the internal factors and the strategies, we will focus our discussion on the results of the regression analysis conducted to test their relationship in the latter part of this section.

6.4.1 Internal organizational environment and supply chain sustainability strategies of the oil and gas industry

A descriptive analysis is conducted to examine the extent of companies' commitment to sustainability, their management preparedness for sustainable practices, and the level of the companies' adoption of sustainable supply chain strategies. Generally, the analysis shows that the companies are rather committed and fairly prepared to implement SSCM practices. Similarly, their implementation of sustainable supply chain strategies is relatively encompassing; no particular supply chain functional area is lagging too far behind. However, the implementation level of the strategies in general is rather moderate, indicating that significant improvements are needed in their current practices. Below, we discuss these findings in more details.

Table 6.8 shows the results of descriptive analysis for the items used to measure companies' commitment to sustainability (CTS).

Table 6.8 – Results of descriptive analysis of commitment to sustainability

	Mean	Std. Deviation
Top management leadership (LEA)	***3.69***	***0.75***
Key role in creating sustainability values	3.78	0.82
Generates consensus on future direction for sustainable development	3.65	0.84
Encourages long-term strategic thinking in sustainable development	3.78	0.91
Provides resources for employees to learn sustainability related knowledge	3.56	0.85
Organizational culture (CUL)	***3.59***	***0.62***
Open	3.72	0.90
Competitive	3.78	0.91
Team oriented	3.94	0.80
Proactive	3.67	0.94
Innovative	3.62	0.97
Flexible	3.74	0.93
Opportunistic	3.28	0.99
Risk taker	2.99	0.89
Transparency (TRA)	***3.26***	***0.91***
Ensures that sustainability performance measurement system is continually improved	3.48	1.01
Regular updates of sustainability performance on the corporate website	2.93	1.17
Invites stakeholders for company visits	3.28	1.13
Prompt response to any sustainability-related inquiry/report	3.42	1.09
Provide guidance & clarification on company's operations to stakeholders	3.59	0.97
Performance disclosure based on sustainability guidelines	2.83	1.40

Among CTS factors, top management leadership (LEA) has the highest mean score. The respondents claimed that the managers of the companies studied demonstrate a key role in creating sustainability values and encourage long-term strategic thinking in sustainable development; the mean score of both of these aspects are 3.78. In terms of organizational culture (CUL), it appears that the companies are ingrained with a rather high level of culture

that promotes teamwork (3.94), competition (3.78), flexibility (3.74), proactive behaviour (3.62) and innovation (3.62). These traits are extremely important in any organizations especially for those that operate in highly complex environment like in the O&G industry, which is constantly pressured to improve the sustainability of its activities. Transparency (TRA) has the lowest mean score among CTS factors. Further examination of its measurement items indicates that the companies practiced a slightly below than moderate level of regular disclosure of their sustainability performance on their corporate website (2.93 mean score); the lowest mean among all items.

The results of descriptive analysis for the measurement items of management preparedness (PRE) are shown in Table 6.9.

Table 6.9 – Results of descriptive analysis of management preparedness

	Mean	Std. Deviation
Management of macro-environment risks (RMM)	***3.70***	***0.83***
Political condition	3.49	1.05
Economic condition	3.91	0.81
Management of operational risks (RMO)	***3.92***	***0.71***
Law and regulations related to SHE protection	4.19	0.78
SHE risks of products	3.99	0.90
SHE risks of logistical activities	3.80	0.97
Preparedness for emergency situation	3.95	1.00
Ethical business conduct of suppliers	3.77	0.95
Relationship with stakeholders	3.84	0.91
Cross-functional integration (CFI)	***3.35***	***0.89***
SHE impact of operations	3.68	1.08
SHE impact of products	3.41	1.05
SHE impact of logistical activities	3.25	1.02
Resource efficiency	3.12	1.00
Suppliers	3.33	1.04
Stakeholders	3.32	1.12
Performance management (PEM)	***3.07***	***1.03***
Use formal metrics to measure sustainability performance	3.22	1.20
Use formal metrics to quantify sustainability benefits	3.05	1.14
Link sustainability to measurement and reward systems	2.81	1.21
Use information systems to manage sustainability-related data	3.07	1.18
Review company-wide sustainability performance management systems regularly	3.19	1.17

In terms of companies' preparedness to implement sustainable practices, it is not surprising to discover that risk management has the highest mean score; particularly in the management of operational risk (RMO). Among the risks sources examined in this study, we find that the companies monitored law and regulations related to safety, health and environment (SHE) protection to a high extent (4.19). This is followed by the monitoring of SHE risk of products (3.99) and companies' preparedness for emergencies (3.95). For the implementation of cross-functional integration (CFI), our analysis shows that companies used cross-functional teams to manage SHE impact of operations most (3.68). Such teams are used the least in managing the efficiency of their resource utilization (3.12). Performance management (PEM) has the lowest mean score among preparedness factors; companies are managing their performance just slightly above moderate level (3.07). The companies as a whole are relatively behind in using formal metrics to measure sustainability performance (3.22); and in reviewing performance management systems on regular basis (3.19). Particularly, the practice of linking sustainability to measurement and reward systems is quite low (2.81).

In terms of companies' implementation of sustainable supply chain strategies, we find that the implementation is fairly encompassing covering all functional areas studied at above than

moderate level. Their adoption of sustainable production (PRO) strategies has the highest mean value of 3.52, followed by logistics management (LOG) with mean score 3.30, and supplier management (SUP) as well as product stewardship (PSW), the mean score of both functions is 3.18. Table 6.10 shows the results of descriptive analysis for companies' production management strategies.

Table 6.10 – Results of descriptive analysis of production management strategy

	Mean	Std. Deviation
Recycle hazardous waste	3.63	1.33
Recycle waste water	3.23	1.42
Work with suppliers in waste minimization	2.95	1.24
Train employees on occupational health & safety protection	4.25	1.01

Among the items measuring PRO, the extent to which the companies train their employees on occupational health and safety protection is quite high (4.25). This is consistent with our findings that the companies put great effort in monitoring and using cross-functional teams to manage SHE related risks, as mentioned earlier. We also find that the practice of recycling hazardous waste (3.63) is slightly better than the recycling of wastewater (3.23). However, their level of cooperation with suppliers in waste minimization can be improved more (2.93).

The results of descriptive analysis for logistics management practices are shown in Table 6.11.

Table 6.11 – Results of descriptive analysis of logistics management strategy

	Mean	Std. Deviation
Green logistics	***2.91***	***0.92***
Use of multi-modal transport to reduce environmental impact	2.96	1.12
Use of energy efficient vehicles	3.00	1.15
Invest in vehicles designed to reduce environmental impacts	3.02	1.27
Recycle/ reuse container	3.16	1.19
Use of recyclable packaging/pallet systems	2.98	1.18
Require suppliers to take back their packaging/pallet systems	2.80	1.32
Collect packaging/pallet systems from customers	2.58	1.33
Preference for environmental-friendly transport mode	2.78	1.29
Transport safety	***3.69***	***0.98***
Safety & health risks of transport mode	3.65	1.07
Safety & health of drivers (e.g. driving and resting time etc.)	3.77	1.10
Transport safety training for drivers	3.56	1.21
Inspection & maintenance of vehicles	3.77	1.08

As mentioned during the discussion on the results of factor analysis, there are two separate strategies that companies used to manage the sustainability of their logistical activities – green logistics and transport safety. We find that the adoption of transport safety (3.69) strategies is considerably more comprehensive compared to green logistics (2.91). Further analysis of green logistics measurement items indicate that companies recycle or reuse container to a reasonable extent (3.16). When it comes to the use of recyclable packaging or pallet system, the practice is slightly lower (2.98). The extent to which the companies collect packaging/pallet systems from customers (2.58), however, is lagging behind the practice of requiring suppliers to take back their packaging/pallet systems (2.80). It is encouraging to see that the companies are investing in vehicles designed to reduce environmental impacts (3.02). Their use of energy efficient vehicles is moderate (3.00), while the use of multi-modal transport to reduce environmental impact is just slightly below that level (2.96). However, it appears that their preference for environmental friendly transport mode is rather low (2.78).

Table 6.12 shows the results of descriptive analysis for companies' supplier management strategies.

Table 6.12 – Results of descriptive analysis of supplier management strategy

	Mean	Std. Deviation
Supplier selection[5]		
Business conduct	***3.64***	***0.75***
Ability to meet company's sustainability requirements	3.42	0.93
Supplier environmental certification	3.40	1.02
Code of business conduct of supplier	3.62	1.14
Contract compliance	4.12	0.73
Cost/quality	***4.07***	***0.55***
Relative price/cost	4.06	0.75
Supplier's cost-reduction capability	3.60	0.90
Quality of service/product	4.41	0.63
Technical capability	4.20	0.78
Reliability	***3.66***	***0.64***
Supplier firm reputation	3.67	0.87
Supplier financial conditions (i.e. assets and liabilities)	3.64	0.83
Likelihood of long term relationship	3.68	0.89
Proximity/size	***2.80***	***0.82***
Geographical location	3.01	1.07
Size of supplier firm	2.59	0.86
Supplier development	***2.22***	***0.94***
Guide suppliers to have their own environmental & social sustainability programs	2.47	1.06
Go into suppliers' organizations to help them improve sustainability performance	2.10	1.00
Run workshops/seminar to educate suppliers	2.15	1.10
Bring together suppliers in the same industry to share their know-how and problems	2.16	1.16
Local supplier development	***2.70***	***0.82***
Direct relationship with local suppliers	3.42	1.04
Requires foreign suppliers to cooperate with local businesses	2.48	1.07
Facilitate access to credit and financing assistance/options	2.21	1.07

In terms of the sustainability of supplier management practices, we examined companies' supplier selection and development strategies. We find supplier selection practices are based on their business conduct, cost/quality, reliability and proximity/size. This is in line with the existing literature (see for example, Ageron et al., 2012; Choi and Hartley, 1996; Wilson, 1994). It is not surprising to see that cost/quality criteria are the most important in the selection process (4.07) due to the cost- and technology-intensive nature of the O&G industry, which is consistent with a study conducted by Jabbour and Jabbour (2009). This is followed by suppliers' reliability (3.66) and business conduct (3.64). Geographical location and supplier firm size are not as important as the other criteria (2.80), possibly due to geographical dispersion of their activities and government regulations that require the inclusion of local small and medium companies in O&G projects in some countries.

For supplier development, the adoption of strategies that could help suppliers improve their sustainable practices is rather low (2.22). Specifically, the mean score of the extent to which companies guide suppliers to have their own environmental and social sustainability programs is just 2.47. The companies also implement a low level of practices that seek to bring together suppliers in the same industry to share their know-how and problems (2.16) and provide workshops or seminars to educate suppliers (2.15). However, the strategies related to local

[5] All items are measured using five-point Likert scale ("very low" to "very high"), except for supplier selection items that are measured using a different five-point Likert scale ("not important" to "extremely important")

supplier development is slightly better (2.70); particularly in terms of having direct relationship with local suppliers (3.42).

The use of local suppliers or materials are often enforced on companies by local government as part of project licensing agreement (Ngoasong, 2014). In order to increase local businesses' involvement in O&G development, governments or O&G companies themselves may require that foreign suppliers share a percentage of their contract or cooperate with the local businesses. This practice is, however, relatively low among sample companies (2.48). Similarly, the level of assistance given to local suppliers in terms of access to credit and financing options is also low (2.21). The difference between the mean scores of the general supplier development practices and the local supplier development practices could indicate that some sustainability initiatives are not intrinsically company drive, but just a response to government regulations.

The results of descriptive analysis for companies' product stewardship strategies are shown in Table 6.13.

Table 6.13 – Results of descriptive analysis of product stewardship strategy

	Mean	Std. Deviation
Involve potential suppliers during new product development	3.01	1.17
Undertake life-cycle assessment during product design stage	2.98	1.15
Use environment-friendly alternative components/ materials	3.06	1.10
Tailor product safety warning to comply with current and emerging regulations	3.40	1.20
Assess compliance with product safety legislation both where the products are made and in their intended markets	3.64	1.09
Design product packaging to be safe & ecologically sound	3.00	1.22

The product stewardship strategy adopted by companies is generally focused on its impact on safety and health. Specifically, the companies assess their product's compliance with safety legislation both where the products are made and in the intended markets (3.64). They also tailor product safety warning to comply with current and emerging regulations (3.40). However, their use of environment-friendly alternative components or materials is rather moderate (3.06). A similar finding is revealed for the level of potential suppliers' involvement during new product development (3.01). The practice of designing product packaging to be safe and ecologically sound as well as undertaking life-cycle assessment during product design is also at a moderate level, with mean scores 3.00 and 2.98, respectively.

Overall, based on the results of the descriptive analysis we are able to understand the internal organizational environment that characterizes the companies that operate in the O&G industry, as well as the level of their adoption of sustainable supply chain practices. It is encouraging to discover that top management is rather committed to leading companies towards sustainable practices. In addition, the companies appear to be ingrained with an organizational culture that can be exploited to facilitate their adoption of such practices. However, this should also come with the willingness to be transparent about the impacts of their activities on the environment and on society. In that regard, significant improvements in current practices are necessary.

The companies, in general, are relatively prepared to implement sustainable practices especially in terms of the management of operational risks. We find that companies are putting considerable attention on the management of SHE impacts of their operations. This is evident in the level of their monitoring of SHE risks and the use of cross-functional teams in SHE management. Therefore, it is not surprising to see these aspects being imbedded in the companies' supply chain management strategies to a considerable extent; specifically with regard to employees' occupational safety and health training, recycling of hazardous waste as

well as product and transport safety. Although this is a good sign, more efforts should be put into improving these practices. The current practices are still poor, especially in green logistics and product stewardship areas. Companies should also employ more collaborative relationships with suppliers to exploit the synergies that they could create of integrating sustainable practices throughout their supply chains. A systematic performance management system would facilitate these difficult endeavours; which is significantly lacking in the companies' current practices and must be given more attention.

Table 6.14 summarizes the results of the descriptive analysis discussed above, and shows the results of a correlation analysis between internal factors and supply chain sustainability strategies.

Table 6.14 – Results of descriptive and correlation analysis for the main variables

Variable	Mean	SD	LEA	CUL	TRA	RMM	RMO	CFI	PEM	SUP	PRO	PSW
LEA	3.69	0.75	1									
CUL	3.59	0.62	.41***	1								
TRA	3.26	0.91	.61***	.34**	1							
RMM	3.70	0.83	.26*	.01	.34**	1						
RMO	3.92	0.71	.30**	.08	.36***	.46***	1					
CFI	3.35	0.89	.32**	.29**	.42***	.31**	.57***	1				
PEM	3.07	1.03	.61***	.45***	.78**	.13	.20^{+}	.40***	1			
SUP	3.18	0.49	.47***	.36***	.48***	.20^{+}	.41***	.48***	.54***	1		
PRO	3.52	1.02	.32**	.39***	.47**	.18	.32**	.42***	.42***	.27*	1	
PSW	3.18	0.89	.25*	.47***	.36**	.15	.40***	.44***	.40***	.54***	.46***	1
LOG	3.30	0.85	.43***	.29**	.44***	.25*	.54***	.55***	.41***	.60***	.46***	.58***

$^{+}p < 0.10$; $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$

Commitment to sustainability: LEA, CUL & TRA; Management preparedness: RMM, RMO, CFI & PEM; Supply chain sustainability strategy: SUP, PRO, PSW & LOG

We find that the correlations between independent variables are relatively weak for most of them (Cohen and Holliday, 1982). The results could indicate low multicollinearity among the variables, which is important for the subsequent regression analysis. We discuss the results of the regression analysis in the next section.

6.4.2 The relationship between internal factors and sustainable supply chain strategies

The multiple regression analysis was conducted to understand the relationship between internal factors and SSCM practices in the O&G industry. We used three control variables to test the regression model namely company size, revenue and extent of company involvement in the O&G supply chain. The use of these control variables is similar to a study conducted by Albino et al. (2012). Company size and revenue were measured using ordinal scale. In terms of the extent of company involvement, respondents were asked to specify the types of O&G operations that they are involved in. Then, we determine the extent of their involvement along O&G supply chains based on the total number of operations. We organized the regression models according to the following sets:

a. The first set tests the relationship between the internal factors (CTS and PRE constructs), including the control variables, and the construct of sustainable supply chain strategy (Table 6.15).
b. The second set examines the relationship between the internal factors (CTS and PRE constructs), including the control variables, and the sustainability strategy of each supply chain function, i.e. supplier management, production management, product stewardship and logistics management (Table 6.16).

c. The last set tests the relationship between all internal factors used to measure CTS and PRE constructs, including the control variables, and the strategy of each supply chain function (Table 6.17).

In order to ascertain that multicollinearity is not an issue in our data, we examined the variance inflation factor (VIF) of the models. The largest VIF score in all the models is 3.33. This is well below the maximum level of 10.0 suggested by Mason and Perreault (1991) for multicollinearity to cause unstable regression coefficients.

a. The relationship between internal factors and sustainable supply chain strategy

The regression analysis in Table 6.15 shows the influence of CTS and PRE on supply chain sustainability strategy. The models included in the table are without (Model 1) or with (Models 2 to 5) the inclusion of control variables.

Table 6.15 – Regression results between the constructs of internal factors and sustainable supply chain strategy construct

	Sustainable supply chain strategy				
Variables (n = 81)	Model 1	Model 2	Model 3	Model 4	Model 5
Commitment to sustainability (CTS)	0.29^{**}	0.28^{*}	0.27^{*}	0.26^{**}	0.27^{*}
Management preparedness (PRE)	0.48^{***}	0.51^{***}	0.54^{***}	0.42^{***}	0.54^{***}
Control variables					
Size		-0.04			0.06
Revenue			-0.08		-0.09
Extent of activities in SC				0.05	0.02
Regression results					
F	40.11^{***}	26.90^{***}	27.55^{***}	26.95^{***}	16.117^{***}
R^2	0.51	0.52	0.52	0.51	0.53
Adjusted R^2	0.50	0.50	0.51	0.49	0.49

$^{+}p < 0.10$; $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$

The analyses indicate that all models are highly significant where about 50% of the variation in the strategy can be explained by the two constructs. We also find that commitment and preparedness have statistically significant positive relationship with sustainable supply chain strategy. PRE has the largest and highly significant coefficient in all models, indicating that it is the most important factor, statistically, that could affect the strategy. We think that the extent of company's commitment and preparedness signify its orientation towards SSCM practices – the more sensitive a company is towards the impact of its supply chain on the environment and society, the more efforts will be put in improving the supply chain sustainability. None of the control variables included in the models has statistically significant relationship with the supply chain sustainability strategy of the companies.

b. The relationship between internal factors and sustainability strategy of each supply chain function

Table 6.16 shows the results of the regression analyses for the influence of CTS and PRE on the sustainability strategy of each supply chain function; the analyses with control variables are included in the table as well (SUP2, PRO2, PSW2 and LOG2).

The models of all regression analyses, with and without control variables, are highly significant. Approximately 25% to 39% of the variance in the strategy of each supply chain function is explained by CTS and PRE, where supplier and logistics management strategy have the highest explained variance. Generally, we find companies' preparedness has a highly

significant and strongest positive effect on SUP and LOG; the relationship between PRE and PSW strategy becomes very significant when control variables are included in the model. Although the factor has a weak significant relationship with PRO, the inclusion of control variables causes an even less effect on the strategy. A similar finding is revealed in the relationship between CTS and PSW. Commitment, however, has the strongest positive relationship with PRO. The increase in commitment is also found to lead to a greater focus on sustainability of SUP practices.

Table 6.16 – Regression results between the constructs of internal factors and sustainability strategy of each supply chain function

	Sustainable supply chain strategies							
Variables (n = 81)	SUP1	SUP2	PRO1	PRO2	PSW1	PSW2	LOG1	LOG2
CTS	0.28^{*}	0.21^{+}	0.34^{**}	0.37^{**}	0.29^{+}	-0.11	0.14	0.12
PRE	0.40^{**}	0.52^{***}	0.24^{+}	0.21	0.32^{*}	0.48^{***}	0.52^{***}	0.57^{***}
Control variables								
Size		0.11		-0.12		0.22		-0.13
Revenue		-0.26^{+}		0.21		-0.35^{*}		0.01
Extent of activities in SC		0.02		-0.06		0.06		0.08
Regression results								
F	24.35^{***}	10.91^{***}	15.50^{***}	6.54^{***}	14.29^{***}	7.21^{***}	24.28^{***}	10.48^{***}
R^2	0.38	0.43	0.28	0.31	0.27	0.33	0.38	0.42
Adjusted R^2	0.37	0.39	0.27	0.26	0.25	0.29	0.37	0.38

$^{+}p < 0.10$; $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$

Among the control variables included in the analyses, revenue has a significant negative effect on SUP and PSW strategy, indicating that companies with lower revenue are more likely to focus on improving the sustainability of these practices. The efforts taken could be focused on improving the efficiency of sourcing practices, tighter cooperation with suppliers to streamline supply chain activities and through product stewardship practices aimed at waste reduction. These strategies could help companies with lower financial capabilities to utilize their resources more effectively and eliminate unnecessary processes that could be done more efficiently through close partnership with suppliers.

c. The relationship between each internal factor and sustainability strategy of each supply chain function

In order to increase our understanding on the internal factors of SSCM practices in the O&G industry, we analyzed the relationship between each of the internal factors that measure commitment and preparedness and sustainability strategy of the four supply chain functions examined. The results are as shown in Table 6.17.

We find that all regression models are highly significant, where the internal factors are able to explain approximately 37% of the variance in SUP, 27% of the variance in PRO, 34% of the variance in PSW, and 39% of the variance in LOG strategy. A closer look at the results reveals that there are only few statistically significant relationships among the factors. We hypothesized that all of the internal factors will affect companies' sustainable supply chain strategies. However, the effects vary where top management leadership (LEA) has no significant relationship with the strategies of any of the supply chain functions. Similarly, transparency (TRA) has a weak relationship with PRO, and no significant relationship with the other three functions. This shows that attempts to empirically test the relationship between these factors may produce results that do not look as great as on papers or frameworks. Nevertheless, the analyses allow us to identify the internal factors that can significantly affect the implementation of SSCM in the O&G industry.

Table 6.17 – Regression results between all internal factors and sustainability strategy of each supply chain function

		Sustainable supply chain Strategy							
	Variables (n = 81)	SUP1	SUP2	PRO1	PRO2	PSW1	PSW2	LOG1	LOG2
CTS	LEA	0.13	0.12	-0.06	-0.05	-0.17	-0.17	0.15	0.14
	CUL	0.10	0.04	0.24^{*}	0.31^{*}	0.38^{***}	0.31^{**}	0.07	0.06
	TRA	-0.03	-0.03	0.29^{+}	0.25	0.03	0.05	0.06	0.06
PRE	RMM	-0.02	-0.06	-0.03	-0.03	-0.02	-0.04	-0.05	-0.06
	RMO	0.22^{+}	0.24^{+}	0.12	0.11	0.31^{*}	0.32^{*}	0.33^{**}	0.32^{*}
	CFI	0.18	0.22^{+}	0.17	0.12	0.12	0.19	0.26^{*}	0.30^{*}
	PEM	0.33^{*}	0.34^{*}	0.03	0.05	0.20	0.19	0.07	0.08
	Control variables								
	Size		0.17		-0.16		0.20		-0.03
	Revenue		-0.26^{+}		0.26^{+}		-0.26^{+}		-0.02
	Extent of activities in SC		0.02		-0.02		0.11		0.14
	Regression results								
	F	7.71^{***}	5.80^{***}	5.22^{***}	3.83^{***}	6.94^{***}	5.49^{***}	8.44^{***}	6.12^{***}
	R^2	0.43	0.46	0.33	0.36	0.40	0.45	0.45	0.47
	Adjusted R^2	0.37	0.38	0.27	0.27	0.34	0.37	0.39	0.40

$^{+}p < 0.10$; $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$

Generally, among commitment to sustainability factors, we find that organizational culture (CUL) has statistically significant positive relationship with PRO and PSW. This suggests that companies that are more ingrained with organizational culture that promote, for example, team collaborations, competitive, risk taking and proactive behavior are the ones that are more likely to initiate innovative safety precautions and pollution prevention measures during production process as well as throughout the life-cycle of a product. The findings are in line with existing studies that shows companies' adoption of SSCM practices is stimulated by sustainability culture and an ability to acquire and develop new capabilities to innovatively address sustainability issues (Pagell and Wu, 2009, Walker and Jones, 2012, Paulraj, 2011, Shuen et al., 2014).

It is interesting to see that that top management leadership (LEA) has no significant effect on the strategies, while transparency (TRA) only has a weak significant relationship with companies' adoption of sustainable PRO strategy. Various literatures suggest that these factors can contribute towards better SSCM practices, see for example Thurner and Proskuryakova (2014), Harms et al. (2013) and Pagell and Wu (2009). The findings could indicate that commitment by top management and improvement of transparency of sustainability-related initiatives alone might be insufficient to enhance the implementation of sustainable supply chain strategies. These commitments must be supported by an organizational culture that can translate them into actual plans and actions (Pagell and Wu, 2009). However, more studies are needed to validate this assumption.

Shuen et al. (2014) stress that a supportive organizational culture can help companies in the O&G industry to develop dynamic capabilities that can improve health, safety, security and environmental management of operations. The capabilities will also enable the companies to manage their increasingly complex business ecosystem caused by, for instance, greater competition to access O&G reserves, as well as the need to rapidly deploy new technologies and operate in remote or unstable operating environments (Shuen et al., 2014). To exploit the capabilities, companies must develop greater cooperation with supply chain partners and stakeholders to minimize the risks involved in their activities.

With regard to management preparedness factors, our analyses reveal that management of operational risks (RMO) has a significant positive relationship with the sustainability strategy of all supply chain functions, except for PRO strategy. Its effect on SUP strategy, however, is relatively weak, compared to other functions. Nevertheless, the positive relationship indicates

that increased monitoring of various sources of operational risks along the O&G supply chain will result in companies putting greater emphasis on sourcing practices that can enhance suppliers' environmental and social performance. It can also build mutually beneficial relationships between supply chain partners to find solutions to sustainability issues. Similarly, companies will be encouraged to implement better product stewardship initiatives if they have greater understanding of the risks involved in producing and delivering O&G products throughout its life-cycle. Management of operational risks may also enhance the sustainability of logistics practices in the O&G industry. The long distance between O&G production facilities and markets involving a complex network of supplying companies requires logistics solutions that are able to reduce its associated safety and environmental risks. These findings support Carter and Rogers (2008) suggestion that risk management is an important supporting facet of SSCM practices.

The O&G supply chain activities involve technology- and engineering-intensive activities at some of the world's most difficult and fragile environments. This can cause adverse impacts if conducted irresponsibly, as demonstrated by the Deepwater Horizon accident in the Gulf of Mexico in 2010. Therefore, effective risk management is necessary to reduce the operational risks involved to prevent disruption in supply chain activities and secure the energy supply, while taking appropriate measures to minimize its environmental and social impacts.

A study by Andersen and Mostue (2012) reveals that involvement of interdisciplinary teams, experts and supply chain partners is important in reducing risks in petroleum industry operations. In line with their finding, our analysis shows that cross-functional integration practices employed by companies in this study have a positive effect on LOG strategy, and on SUP when control variables are included in the analysis. According to Porter (1991), cross-functional integration could create a cohesive working environment and allows various functional departments to work towards common sustainability goals.

This is especially important to the O&G industry due to the global nature of its operations, which according to Escobar and Vredenburg (2011), necessitates the use of sustainability strategies that can be implemented across different functional areas and companies' network of subsidiaries. They further suggested that the implementation of the strategies in different areas of the O&G value chain must be guided by business-level strategies such as green consumerism and reduction of legal liability, cost and risk exposure. The strategies must also be complemented by environmental capabilities such as pollution control and prevention measures (Escobar and Vredenburg, 2011). Yusuf et al. (2013), for instance, found that the majority of the UK's O&G companies involved in their study applied sustainability strategies like energy efficiency and waste management measures across different operations, such as in supply chain management, as well as transportation and logistics.

Sustainability of sourcing and logistics activities can be influenced by decisions made in other supply chain functions such as production, and vice versa. For example, O&G development in difficult environments such as in deepwater or in politically unstable locations could affect procurement and supply planning strategy. It could also determine scheduling, inventory management and transport infrastructure options that can be employed (Tesfay, 2014). The size, shape and materials of product packaging also have a strong relationship with sustainable logistics (Sarkis, 2003). Therefore, effective collaboration and coordination among different supply chain functions is vital to supply chain sustainability.

It is rather interesting that we only find a significant relationship between CFI with supplier and logistics management, but not for the other functions. The risks associated with the O&G supply chain are directly connected to the costs of acquiring its products and supplies. There is also considerable environmental burden in transportation activities because it involves distribution and discovery of new and used products (Tsoulfas and Pappis, 2008).

Perhaps, practices that can strategically control and minimize risks right from the initial source of materials and services used in O&G production processes could create a trickle effect that can enhance the overall supply chain sustainability. For example, this could include supplier selection based on the performance of their business conducts, or use of environmental friendly substitutes for raw materials and transport modes. Increased cross-functional coordination efforts in these areas could facilitate efficient resource utilization, thereby helping companies eliminate supply chain risks more effectively (Frankel and Mollenkopf, 2015). Logistics operations involve various activities such as inventory management, warehousing as well as management of inbound and outbound flow of goods/services. Cross-functional integration can help companies streamline these operations and address the pressures for more sustainable logistics management practices efficiently (Lai and Wong, 2012).

Further analysis of the relationship between the internal factors and sustainable supply chain strategy shows that performance management has a significant effect only on improving the sustainability of SUP practices. The O&G industry's operations involve complex networks of specialized suppliers and service providers – for example, the materials and services needed to maintain the activities of an offshore O&G platform can be compared to supplying a small city. According to Wagner and Armstrong (2010), companies in the O&G industry are increasingly pressured to improve the traceability of materials used in production processes to reduce environmental impacts. The management of these complex processes requires performance management systems that could help companies to enhance supply chain coordination and efficiency, as well as to identify suppliers that could help them integrate environmental and safety measures in the supply chain.

Hervani et al. (2005) find that the development of performance measurement systems and the associated requirements can facilitate the introduction and implementation of sustainable practices in supply chain. However, it is crucial for a company to define the sustainability goals which its performance can be measured against, so that opportunities for further improvement can be identified and addressed more effectively (Schaltegger and Burritt, 2014). Faisal (2010) proposes that the use of performance measurement metrics can help companies to quantify their performance and identify actions needed to improve SSCM implementation.

Of the control variables included in the regression analysis, only revenue has a significant relationship with sustainability strategy of the supply chain functions. Specifically, it appears that companies with lower revenue may emphasize improving SUP and PSW practices; while those with higher revenue may focus on enhancing the sustainability of PRO practices. Zhu et al. (2007) found that close cooperation with suppliers in eco-design programs facilitates better communication, improves efficiency and reduces costs, which could translate into better environmental performance because fewer resources are consumed and less waste is discarded. Similar results were found by Tesfay (2014) in their study on improving coordination between an O&G company and its sea transport supplier.

Studies have also shown that the cost of SSCM practices has a negative effect on its adoption (Giunipero et al., 2012, Campbell, 2007). This could indicate that companies with lower financial capability, when pressured to improve supply chain sustainability, focus on measures that do not require significant financial investment or could reduce cost. For example, through streamlined managerial processes and better coordination and cooperation with suppliers and customers, to increase supply chain efficiency and reduce resource consumption.

Improvement of production process sustainability, on the other hand, may require significant investment that could drain financial resources of less profitable companies. For example, the cost of initial regulatory compliance and further increase in regulation stringency

of oil refineries' air quality is estimated to be around $3 million and $5 million per plant, respectively (Berman and Bui, 2001); the annual cost increase of offshore O&G drilling safety requirements introduced after the Deepwater Horizon is approximately $183.4 million (McAndrews, 2011). This shows how cost-intensive the implementation of sustainable practices in O&G development, especially when it requires improvements in existing production technology and infrastructure. Therefore, companies with higher revenue can be expected to spend more on improving the sustainability of production management practices compared to less profitable companies.

In the next section, we will present our main findings based on the results of data analysis and their implications.

6.5 Conclusion and implications

This chapter seeks to understand the internal factors of SSCM practices in the O&G industry. It explores the relationship between commitment to sustainability factors and management preparedness factors with sustainability strategy of four supply chain functional areas: supplier management, production management, product stewardship and logistics management. The main findings of our analyses are as follows.

First, companies' commitment and preparedness for sustainable practices can enhance the implementation of SSCM strategies. However, their preparedness (with regard to risk management, cross-functional integration and performance management practices) appears to be the most important factor that could affect the extent of the implementation.

Second, while commitment to sustainability can drive the introduction and implementation of SSCM practices in a company, companies must have the capabilities to translate the commitments into real strategies and actions. We find that companies with an organizational culture directed towards open communication, team collaboration, proactive, innovative and risk taking behaviour are more likely to implement better supply chain strategies. Specifically, our analyses reveal that an increase in organizational culture that promotes sustainable behaviour can improve the implementation of production management and product stewardship practices.

Third, management of supply chain operational risks is important to improving the sustainability of supplier management, product stewardship and logistics management practices. Every company must be able to identify and monitor risk factors that could cause adverse social and environmental impacts, disrupt supply chain activities and affect its reputation. This will allow them to find supply chain solutions that are able to strategically address the risks. Our findings suggest that the management of the risks should involve: (a) supply management practices that emphasize responsible business conduct of suppliers and preference for environmental friendly source materials, (b) proactive management of the impact of processes and products throughout their life-cycle, and (c) logistics solutions that facilitate efficient, safe and closed-loop transportation and distribution of supplies and services.

Lastly, the adoptions of sustainable supplier and logistics management strategies are the main supply chain functional areas that can be affected by the different management preparedness factors studied (i.e. management of operational risks, cross-functional integration and performance management). This finding can indicate the central importance of these functions to the implementation and achievement of sustainable supply chain practices. This could be attributed to the role that they play in coordination of acquisition and distribution activities in supply chains. Therefore, companies must be able to create synergies among different management preparedness aspects and supply chain functional areas in order

to implement SSCM strategies more effectively. This study does not test the interaction effect between these factors. Therefore, future research could examine their relationships further.

Several opportunities for future research are identified to improve our understanding of the internal factors of SSCM practices in the O&G industry. In this study, we used cross-sectional data to understand the relationship between the internal factors and sustainable supply chain strategies. Future research could employ a longitudinal study to obtain a clearer picture of how the internal factors could change companies' strategies over time. A case study could also be conducted to distinguish the SSCM strategies employed by companies that operate in different O&G supply chain segments. This would help us to understand the strategies used at a supply chain level and the effects of the dynamics among supply chain partners on the strategies.

Overall, the findings of this study can be used by companies in the O&G industry, to plan and design SSCM strategies to address the pressure for more environmentally and socially responsible activities in the supply chain. The factors examined constitute organizational resources and capabilities that could be developed, in order to enhance companies' ability to balance this pressure with their economic goals. Companies must be able to develop SSCM strategies that could strategically exploit the capabilities and available resources in their supply chains to achieve the balance.

To the best of our knowledge, this is the only study that explores SSCM practices in the O&G industry in four different supply chain functions. We believe that the findings are useful for enhancing our understanding of current SSCM practices in the industry. It also helps to validate SSCM theories related to internal factors that could drive (or hinder) its implementation.

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7. Conclusion and implications

7.1 Introduction

The oil and gas (O&G) industry plays an important role in sustainable development because it is essentially the industry that powers economic and social activities. Due to various environmental impacts that are often associated with O&G development and use, the industry is increasingly pressured to improve the sustainability of its supply chains. However, current research on sustainable supply chain management (SSCM) practices in the O&G industry is still fragmented. Specifically, there is a lack of understanding on the contextual factors within the industry's external business environment and internal organizational environment that can influence its adoption of the practices. In addition, none of the existing studies examine how the factors can influence the sustainability strategies of different supply chain functions. Therefore, this thesis proposes a multidimensional conceptual framework of SSCM for the O&G industry context and conducted several studies to address this knowledge gap, qualitatively and quantitatively.

In order to gain an overview of sustainable practices in the O&G industry, we analyzed the content of sustainability reports of 30 O&G companies. Specifically, we examined the extent of companies' disclosure of their intent for sustainable practices as well as their performance related to environmental and social sustainability. In addition, we analyzed the strategies that they used to integrate sustainability into their supply chain management (SCM) practices. We also conducted a survey among academic experts in the SSCM and O&G field to gain their perspectives regarding the important external factors that can influence SSCM practices in the O&G industry. Another survey was conducted among companies that operate along the upstream and downstream O&G supply chains to empirically test the relationships proposed in the conceptual framework of this thesis.

In this final chapter, we will first summarize the findings of our studies in Section 7.2 and discuss their implications to the SSCM field, particularly to SSCM studies in the O&G context. The following Section 7.3 discusses the managerial implications of our findings. Section 7.4 presents recommendations for future research. Finally, Section 7.5 concludes this thesis with some final remarks.

7.2 Substantive findings and scientific implications

In this section, we discuss the findings according to the research questions posed in Chapter 1. Specifically, we will first describe the factors within the O&G industry's internal and external contextual environments (RQ1). This is followed by a discussion on the implementation of SSCM strategies among companies in the industry (RQ2). Next, we focus on companies' reporting of their commitment to sustainable practices and performance (RQ3). The following subsection is about the importance of external factors in influencing SSCM practices in O&G industry (RQ4). Finally, we discuss how the internal and external contextual factors can affect the implementation of SSCM practices in the industry (RQ5).

7.2.1 Internal and external environments of the oil and gas industry

Halldórsson et al. (2009) suggest that the appropriate strategy needed to address supply chain sustainability issues may be different for every industry and product. The lack of SSCM research in the O&G industry context necessitates studies that examine the contextual factors of its SSCM practices. This will allow us to identify supply chain solutions that are more applicable to the industry context, thus help improve its implementation of SSCM practices.

The first research question of this thesis aims to identify the external and internal contextual factors that could influence its SSCM practices. The research question is as follows:

RQ1: What are the factors within the O&G industry's external business environment and internal organizational environment that can influence its implementation of SSCM practices?

We identified the external and internal factors through a literature review, as discussed in Chapter 2. The external factors that we found as revelant to this study are: political stability, economic stability, stakeholder pressure, competition, energy transition and regulations. For the internal factors, we focused on companies' supply chain sustainability goals, commitment to sustainability and management preparedness. The factors were further examined using data gathered from surveys, which we discussed in Chapter 4 to Chapter 6.

Through our analyses, we are able to describe the industry's external business environment and internal organizational environment. The external and internal factors studied in this thesis, until now, have not been examined in an SSCM study in the O&G industry context. We add to the existing knowledge about these factors by identifying:

1. The extent to which the external factors create pressures on O&G companies' activities;
2. Supply chain sustainability goals that companies in the O&G industry focus on; and
3. The extent of O&G companies' commitment to and preparedness for sustainable supply chain practices, and improvement opportunities of these aspects.

Generally, our analyses show that the companies studied operate in a relatively stable external business environment, where the factors within the environment exerted a moderate pressure on them. Specifically, the companies experienced a rather stable political environment, i.e. infrequent to occasional incidences originated from governmental and societal sources that can cause instability or disturbance to their operations. Similarly, the economic conditions enabled them to moderately invest in planned business expansion and sustainability initiatives, which can indicate a fairly stable economic environment. However, these findings may not be generalizable to the whole O&G industry since some companies

operate in highly unstable environments due to, for example, civil war and economic sanctions (Al-Damkhi et al., 2009; Almohamad and Dittman, 2016).

Our analyses also show that the level in which companies involved their stakeholders to help them address sustainability issue at strategic level is moderate. We also find that companies in the O&G industry can be affected by competition from within its industry more than the competition from the broader energy industry. In addition, the companies perceived that energy transition and regulatory pressure have low to moderate effects on their activities. With regard to energy transition, the companies revealed that the imposition of fiscal, taxation or other measures to promote low carbon/renewable energy during the energy transition has the highest effect on them. Meanwhile, for the regulatory factor we find that cost related to compliance and remediation factor could affect companies' operation most.

In terms of the internal factors, specifically supply chain sustainability goals, our analyses reveal that there are two types of sustainability goals that O&G companies pursue. We categorized the goals as: (1) strategic sustainability goals (related to long-term survival of a company), and (2) functional sustainability goals (related to company's operational processes in supply chain management). We find that the companies are equally focused on both strategic and functional goals. Further analysis of individual strategic goals shows that companies are highly focused on safety, health and environmental (SHE) management. For the functional goals, the companies focused mainly on product responsibility.

We assessed companies' commitment to sustainability based on the level of top management leadership, organizational culture and transparency. We discover that top management of companies is moderately committed to leading their organizations towards sustainable practices. In addition, the companies appear to be ingrained with organizational cultures that promote teamwork, competitiveness, flexibility, proactiveness and innovation. These cultures can be exploited and further harnessed to facilitate their SSCM implementation. However, this should also come with the willingness and ability to be transparent about the impacts of their activities on the environment and society. In that regard, we find that significant improvements are needed to increase the transparency of companies' sustainability practices and performance.

We measured management preparedness to implement SSCM practices in terms of companies' risk management, cross-functional integration and performance management practices. Our analyses reveal that the companies are relatively prepared to implement SSCM, especially in monitoring the operational risks that can affect the sustainability of their supply chains. The companies, in general, are putting considerable attention on managing the impacts of their operations on the environment, safety and health. This is evident in the level of their monitoring of SHE risks and the use of cross-functional teams in SHE management. In terms of the management of sustainability initiatives' performance, there is just a moderate use of formal metrics to measure sustainability performance. In addition, the practice of linking sustainability to measurement and reward systems is particularly low.

Overall, we find that the companies involved in this study experienced a relatively stable external business environment. The factors within the environment exert low to moderate pressure on them. In terms of the internal organizational environment, our analyses show that the companies' are just moderately committed and prepared to implement SSCM practices. Therefore, further improvements are necessary so that companies could effectively address the changes in their operating environment and pressure to operate sustainably in timely manner. We find that the areas that require their attention most are transparency of sustainability initiatives, performance management and cross-functional integration practices.

7.2.2 Sustainable supply chain management strategies of the oil and gas industry

The adoption of sustainable supply chain strategies among companies in the O&G industry was assessed through an industry survey, as discussed in Chapter 6. It enabled us to answer the second research question of this thesis, which is as follows:

RQ2: What are the sustainable supply chain strategies adopted by companies in the O&G industry?

In order to answer this question, we focused on sustainability strategies related to supplier management, production management, product stewardship and logistics management. Existing SSCM studies in the O&G industry context are mostly focused on specific supply chain function and sustainability dimension. The multi-functional focus of this thesis adds to the existing knowledge in the following aspects:

1. Provide a more encompassing overview of the implementation of sustainable supply chain strategies in the O&G industry;
2. Identify the main supply chain function and sustainability aspects that companies focus on; and
3. Identify improvement opportunities in the industry's current implementation of SSCM practices.

The results of our data analyses show that the extensiveness of companies' implementation of sustainable supply chain strategies is generally at a moderate level. Overall, their adoption of sustainable production management strategies is the most comprehensive, followed by logistics management, supplier management and product stewardship. Specifically, the analysis reveals that companies are highly focused on training employees in aspects related to SHE management of production activities. This is consistent with the findings that there is a high level of SHE risks monitoring among the companies, and of using cross-functional teams to manage the impacts of their operations on the environment, safety and health.

As discussed in Chapter 6, we found two separate strategies that companies used in logistics management, namely green logistics and transport safety. Further analysis indicates that the implementation of transport safety strategies among the companies is higher than their implementation of green logistics strategies. Transport safety strategies are focused on safety and health protection for drivers (e.g. driving and resting time), as well as inspection and maintenance of vehicles. The analysis of green logistics strategies indicates that there is a moderate use of recyclable packaging or pallet systems. We find that while companies require suppliers to collect their packaging/pallet systems, the companies themselves are lagging behind in adopting the same approach. In terms of transport choices, the companies are making moderate investments in acquiring vehicles designed to reduce their environmental impacts. Their use of energy efficient vehicles and multi-modal transport modes are also at a moderate level.

In this thesis, the supplier management strategies examined are related to companies' supplier selection and development practices. We find that cost/quality criteria are the most important factors in their supplier selection process, followed by suppliers' reliability and business conduct. Our findings also indicate that the adoption of strategies that could help suppliers improve the sustainability of their practices is rather low, especially in terms of promoting knowledge sharing among suppliers. The implementation of local supplier development practices is slightly better, particularly in terms of having direct relationships with local businesses.

Our analyses regarding the product stewardship strategy adopted by companies in the O&G industry show that they are rather focused on: (1) assessing product compliance with

safety legislation both where the products are made and in the intended markets, as well as on (2) tailoring product safety warnings to comply with current and emerging regulations. However, we find that there is a moderate use of environment-friendly alternative components or materials in their operations. The involvement of potential suppliers during new product development activities is also moderate. Similar findings were obtained for the companies' adoption of the practice of designing product packaging to be safe and ecologically sound, as well as for undertaking life-cycle assessment during product design.

Overall, we find that companies are putting moderate efforts on integrating sustainable practices in their supply chains activities. The companies, however, are highly focused on managing the impacts of their activities on the environment, safety and health. However, more efforts should be put into improving these practices especially with regard to the strategies that could address the environmental impacts of supply chains through green logistics and product stewardship implementation. We also think that companies should employ more collaborative relationships with suppliers. This will help companies to exploit the potential synergies that can be developed through sharing of expertise, resources and experiences with their supply chain partners. Improvement in these areas could help increase overall sustainability performance of O&G supply chains.

7.2.3 Communication of sustainability intention and performance

A review of literature related to sustainability reporting shows that there is a lack of studies that focus on the reporting practices and the integration of sustainability in SCM practices in the O&G industry context. Therefore, we conducted a content analysis that aims to identify the extent to which O&G companies communicate their intention (commitment) and performance in sustainable practices. Findings from this study helped us answer the third research question of this thesis:

RQ3: To what extent do companies in the O&G industry communicate their commitment and performance related to sustainable practices?

Chapter 3 discusses the results of the study conducted to answer this question. Sustainability reports provide rich sources of secondary data that can be used to identify companies' sustainability strategy and assess their performance. This thesis adds to the existing knowledge about sustainability reporting practices in the O&G context, where we:

1. Assess O&G companies' intention and performance related to environmentally and socially responsible practices;
2. Identify improvement opportunities in sustainability reporting practices of the O&G industry.

Our analyses of sustainability reports of 30 O&G companies revealed that the companies, in general, developed clear sustainability policies and visions that outline their commitments for environmentally and socially responsible practices. However, there is a tendency for the companies to discuss the intention to improve the sustainability of their practices more than to report their actual performance. Furthermore, we find that there are inconsistencies in the discussions of their intentions for sustainable practices with the reporting of their sustainability performance. Generally, most companies expressed higher environmental intent compared to social intent, but reported more extensive social performance data than environmental performance data. This findings is consistent with Clarkson et al. (2008) study. Environmental intent, social intent and social performance reporting are dominated by qualitative indicators. The lack of reporting of measurable (quantitative) environmental and social performance data caused the O&G companies' sustainability reports to be rather

narrative or descriptive. This prevents interested stakeholders from assessing the companies' progress in sustainable practices in a more objective and informed manner. Consequently, the reports can be perceived as a form of green-washing.

In Chapter 3, we also analyzed the reporting practices of companies with different financial performance. The findings indicate that a good financial position is a necessary but not a sufficient factor for comprehensive disclosure of sustainability initiatives and performance. Studies have shown that financial resources can determine companies' ability to implement more sustainable practices (Campbell, 2007, Giunipero et al., 2012). However, other organizational factors, such as management's sustainability orientation and organizational culture (Walker and Brammer, 2012, Hussain, 2011, Pagell and Wu, 2009), can also encourage a more transparent reporting of sustainability performance.

In terms of the integration of sustainable practices in SCM, the reporting of this aspect in sustainability reports differ greatly among the companies studied. The reports as a whole, however, provide a rather good overview of companies' sustainability strategies related to supplier management, product stewardship and logistics management practices, as well as the challenges that they faced in implementing the strategies. Overall, we find that significant improvements are needed in the extensiveness of companies' reporting of their SSCM strategies and performance. For example, companies tend to discuss the strategies that are used to improve the sustainability of supply chain activities. However, they failed to disclose the actual impacts of the strategies implementation on their supply chain performance.

Similar findings were obtained by Morali and Searcy (2010) and Wu et al. (2012) in their studies on the reporting of SSCM practices among other industries. These findings can be attributed to the lack of coverage of supply chain performance indicators in sustainability reporting guidelines used by the companies. However, the lack of indicators alone cannot be assumed as the only explanation for the lack of disclosure, as shown by our analyses of their sustainability intent and performance reporting. Companies' willingness and capabilities to report sustainability performance more comprehensively and transparently can contribute towards the extensiveness of their disclosure.

7.2.4 The importance of external factors in influencing SSCM practices in the O&G industry

We conducted a survey among academic experts in the SSCM and O&G fields to further examine the external factors of the O&G industry supply chain. Specifically, the survey aims to answer the following question:

RQ4: What are the most important external factors that can influence the O&G industry's adoption of SSCM practices?

Although various studies have been conducted to examine the external business environment of the O&G industry, a formal and detailed discussion of the importance of the external factors to SSCM practices in the industry context is largely absent. This gap must be addressed in order to improve our understanding of the external factors that could affect its implementation of the practices. We add to the existing knowledge by identifying the most important external factors through the use of a new multi-criteria decision making (MCDM method) called Best Worst Method (BWM). This can help companies to determine the external factors that can be their main focus and the strategies that can be used to improve the sustainability of their supply chain management practices. We discussed the findings of this study in Chapter 4.

Generally, our analyses revealed that academic experts think economic stability is the most important factor that could influence the adoption of SSCM practices in the O&G industry.

This is followed by competition, political stability, stakeholder pressure, regulations and energy transition. The high importance given to economic stability may be attributed to its strong tie with oil prices. The factor can determine the profitability of O&G development projects and the investment behaviour of O&G companies (Nuhu et al., 2014). For example, high oil prices can stimulate investment in new production, alternative fuels, and energy efficiency technologies (Mitchell and Mitchell, 2014). Since environmental and social initiatives are also costly (Carter and Rogers, 2008), stable economic conditions enable companies to allocate their resources on supply chain improvements.

In terms of the second most important factor, which is competition, the experts perceived that competition within the O&G industry itself will encourage companies to improve the sustainability of their supply chains. Specifically, the main source of competition in the industry comes from the international oil and gas companies (IOCs), followed by national oil and gas companies (NOCs). The competition from other energy companies of alternative energy sources are the least important. These findings are consistent with the results of our industry survey.

For the third most important factor, which is political stability, we find that political risks related to governmental sources (e.g. energy policies and economic priorities) can affect companies' SSCM practices most, compared to risks related to societal sources (e.g. political unrest and opposition to companies' activities). These findings can be attributed to the role that governments play in controlling local O&G projects. Factors such as O&G production cash flow, prospects for additional exploration activities, and their economic benefits can determine governments' actions, and consequently the potential risks to companies (Van de Putte et al., 2012). Sudden policy changes could occur that can lead to forced renegotiation of project licensing conditions and seize-up of assets. Unstable political conditions, therefore, create an uncertain business environment that could affect companies' investments (Urciuoli et al., 2014), thus their ability (or motivation) to focus on sustainability initiatives.

Stakeholder pressure is the fourth most important factor. It is not surprising to discover that the experts perceived 'government' as the most important stakeholder, followed by shareholders, competitors, suppliers, and non-governmental institutions. While academic experts perceived that local communities are among the least important stakeholders, the results of our industry survey indicate that companies engaged with this stakeholder group the most. The least important stakeholder is education institutions. Generally, the results clearly show the influence of power in determining which stakeholder groups could affect corporate strategies related to sustainable development of O&G. They also further emphasize the importance of an integrative approach to stakeholder engagement and collaboration; especially engagement with stakeholder groups that have legitimate claims over the impacts of O&G development, but with less power to negotiate the claims, such as local community. Companies' failure to identify and engage with stakeholders in a way that creates an enduring and mutually beneficial relationship is detrimental to the sustainability of O&G development (Frynas, 2005, Wheeler et al., 2002).

It is rather interesting to discover that regulations are the second least important factor, among the six external factors studied, that could affect SSCM practices in the O&G industry, while existing studies stress the importance of regulatory pressure in driving sustainable supply chain practices (Zhu et al., 2005, Zhu et al., 2007b, Seuring and Müller, 2008). The results indicate that greater competition and stakeholder pressure can stimulate the implementation of SSCM practices, even in an environment with little to no regulatory pressure. Stable economic and political conditions would create a more conducive environment for companies to focus on the implementation of the practices. We expected energy transition to be the least important external factor that can influence the adoption of SSCM practices in the O&G industry. This is due to the relatively slow progress in the

development of alternative and renewable low carbon energy (Verbruggen et al., 2010), which creates little to no pressure for companies to improve the sustainability of their supply chains to compete with the much cleaner energy sources.

Overall, apart from the economic stability factor, the differences in the relative importance of the external factors in influencing the O&G industry's SSCM practices are not large. This could indicate the difficult job that managers face when dealing with external pressures. The external factors are often inter-related and largely beyond companies' control. Companies, therefore, must be equipped with internal resources and capabilities that can help them address the factors effectively to facilitate their implementation of SSCM practices.

7.2.5 Contextual factors of sustainable supply chain management of oil and gas

The final reseach question of this thesis focuses on understanding the relationships between contextual factors and supply chain sustainability strategies of four supply chain functions (supplier management, production management, product stewardship and logistics management). The research question is as follows:

RQ5: What are the relationships between the external and internal factors with sustainable supply chain strategies?

The findings of our analyses allow us to understand the contextual factors that can drive or hinder the implementation of SSCM practices in the O&G industry. We examined the relationships between the factors by focusing on:

1. The relationship between external business environment factors with supply chain sustainability goals (Chapter 5); and
2. The relationship between internal organizational environment factors with supply chain sustainability strategies (Chapter 6).

This thesis argues that companies in the industry will implement sustainable supply chain strategies that are able to align their internal organizational environment with the pressures exerted by their external business environment in order to achieve the companies' supply chain sustainability goals. It adds to the existing knowledge on the factors that can influence SSCM practices, particularly in the O&G industry context. Specifically, this thesis:

1. Identifies the relationships between external business environment factors and supply chain sustainability goals. It positions supply chain sustainability goals as an important element that can determine companies' SSCM strategy by explicitly examining how the goals can be influenced by the external factors. This is the first study that examines such relationship and among very few researches that explicitly incorporates sustainability goals in an SSCM framework;
2. Demonstrates the context dependency of companies' responses to external pressures, specifically, in terms of the differences in companies' responses to competitions and regulatory pressures;
3. Identifies the relationships between internal organizational factors (commitment to sustainability and management preparedness) and sustainable supply chain strategies of four supply chain functions: supplier management, production management, product stewardship and logistics management; and
4. Identifies the strategies that companies can use to address pressures from the external factors and the internal factors that companies can focus on in their implementation of SSCM practices.

The relationships between external factors and supply chain sustainability goals are discussed in Chapter 5. Generally, we find stakeholder pressure has the strongest and most significant relationships with supply chain sustainability goals compared to other external factors. Specifically, companies' focus on strategic and functional sustainability goals are higher when they experience higher stakeholder pressure. This is in line with Seuring and Müller (2008) finding that stakeholder pressure is an important driver of SSCM practices. Garcés-Ayerbe et al. (2012) found that companies will adopt a more proactive sustainability strategy when they perceive greater pressure from stakeholders.

Apart from stakeholder pressure, we find that stable economic conditions will drive companies to focus more on the strategic and functional supply chain sustainability goals. In addition, our analyses reveal that companies will focus more on their safety, health and environmental management practices when they operate in an environment that is politically stable from disturbances originated from societal sources, such as political unrest and opposition to companies operations.

The most interesting findings regarding the external factors concern the influence of competition on companies' focus on the sustainability goals. We find that companies will reduce their focus on strategic sustainability goals when they face greater competition from the broader energy industry, such as from renewable and low carbon energy companies. An increase in competition from within the O&G industry itself, on the other hand, leads to a higher focus on functional sustainability goals. These findings clearly show the interest-seeking nature of companies and that their responses to external competition vary depending on its context. Companies in the O&G industry cannot compete with alternative energy players and sources in sustainability areas, which explains the negative relationship found. They can instead compete in commercial areas based on supply and price. However, when faced with greater competition pressure from its own industry peers, companies are forced to focus on strategies that can differentiate themselves to gain competitive advantage, such as through the adoption of more comprehensive sustainable supply chain practices.

Another interesting findings relate to the differences in the influence of regulatory pressure on specific strategic sustainability goals, namely SHE management and energy security. Our analyses reveal that increased regulatory pressure can drive companies to focus more on SHE management, which is consistent with the findings of Zhu et al. (2007a). However, the pressure has a negative effect on companies focus on energy security. This can be attributed to the cost of sustainability initiatives. According to Harris and Khare (2002), the cost of compliance to regulatory requirements in the O&G industry varies greatly and can be financially draining, especially for smaller companies. This can create strategic and financial risks to companies that can affect their operations, consequently threaten their focus on ensuring uninterrupted energy supply. Companies might also be discouraged to pursue innovative energy technologies that can improve the sustainability of energy supply due to the increase in regulatory requirements (Grekova et al., 2014).

We also found a positive relationship between energy transition and strategic sustainability goals. There are increasing pressures from various groups for reduction in our dependency on O&G due to the environmental issues associated with the energy sources. Although many industries can be affected by the transition, the O&G industry is essentially at the heart of the transition. Any regulatory or fiscal policies introduced to spur the speed of the transition and promote the development of alternative low carbon and renewable energy will affect the industry and its long-term survival. Therefore, companies need to examine their current position against the realities of the current energy systems and also their expectations of the future low carbon energy systems, hence the increased focus on strategic goals. In order to improve their social legitimacy during energy transition, companies in the O&G industry may focus on strategic sustainability goals such as transparency of their sustainability initiatives

and SHE management practices. They may also exploit the policy support given to alternative energy to diversify their energy supply bases. Development of alternative energy may require changes to SHE management due to different developmental needs of the energy sources. However, it can help companies to green their to supply chains and address energy security concerns. This could consequently encourage companies to increase the transparency of their activities to improve their social legitimacy.

Our analyses regarding the relationship between internal factors and sustainable supply chain strategies reveal that companies' commitment and preparedness for sustainable practices may enhance their SSCM implementation. Specifically, companies' preparedness (measured through risk management, cross-functional integration and performance management capabilities) is found to be the most important factor that could affect the extent of the implementation. These findings stress the importance of having appropriate internal capabilities, resources or competences that can facilitate the implementation of SSCM practices. While commitments are also important to the practices, companies must be able to translate the commitments into strategies and actions that can result in actual difference to their adoption of SSCM. More effective implementation of SSCM strategies can be achieved when companies are both committed and prepared to implement the strategies.

An interesting finding that can illustrate the difficulty in integrating sustainable practices in the O&G industry relates to the relationship between management preparedness and supply chain sustainability strategies. We found that preparedness has a strong relationship with sustainability strategies of every supply chain function examined in this study, except with production management. This finding can be attributed to the inflexibility of O&G infrastructural assets, which require massive investments in order to improve the sustainability of O&G development activities. Due to this factor, companies in the O&G industry may prioritize sustainability strategies of supply chain functions that do not require costly investments or major changes in processes and technology. This includes improvements in supplier selection, product life-cycle management, and distribution practices. Companies can exploit the synergies that can be developed through greater cooperation within organization and across supply chain networks to improve these practices.

We measured commitment to sustainability through top management leadership, organizational culture and transparency. While various studies such as Harms et al. (2013) and Thurner and Proskuryakova (2014) stress the importance of top management leadership, we found no significant relationship between this factor and sustainable supply chain strategies. Transparency, on the other hand, has a weak relationship with production management strategy. Our findings also show that companies are more likely to adopt sustainable supply chain practices when they are ingrained with an organizational culture that can promote sustainable behaviour such as open communication, team collaboration, proactiveness and innovation. Further analysis reveals that these cultures can lead to a more sustainable production management and product stewardship practices. This is in line with Pagell and Wu (2009) and Shuen et al. (2014).

Among management preparedness factors examined, we find that the management of supply chain operational risks can improve companies' supplier management, product stewardship and logistics management practices. This supports Carter and Rogers (2008) suggestion that risk management is an important facet of SSCM practices. We also discover that cross-functional integration practices can drive the adoption of more sustainable supplier management and logistics management strategies, which is consistent with the results of Reuter et al. (2010), Andersen and Mostue (2012) and Frankel and Mollenkopf (2015)'s studies. In addition, our analyses reveal that performance management has a significant positive effect on companies' supplier management practices.

The adoption of sustainable supplier and logistics management strategies are the only supply chain functional areas that can be influenced by different management preparedness capabilities, i.e. management of operational risks and cross-functional integration. This finding shows the central importance of these functions to SSCM practices, which is due to their role in coordinating the activities involved in acquisition and distribution of supplies and products throughout O&G supply chains. It also further emphasizes that creating synergy between different supply chain functional areas is vital to SSCM practices, as suggested by (Rezaei et al., 2015). This can be achieved when companies are equipped with internal resources or capabilities that can create a cohesive working environment towards common sustainability goals.

7.2.6 Findings on unique characteristics of the oil and gas industry

This thesis focuses on understanding the influence of external and internal contextual factors on the implementation of SSCM strategies in the O&G industry. In our analyses, we found that the O&G industry exhibits strategic responses to the pressures for sustainable supply chain management practices, i.e. in their employment of strategies that could safeguard their interests.

The factors examined in this study were chosen based on the broader SSCM literature that investigates various industrial areas. Generally, our findings concerning the relationships between these factors and supply chain sustainability strategies in the O&G industry are in agreement with existing insights from this broader literature. However, we found two salient results in our study that may point to the uniqueness of the O&G industry when it concerns the adoption of SSCM strategies under external and internal pressures:

- Concerning external factors, we are able to distinguish two contrasting responses to competition that show the context dependence of the responses. Specifically, on one hand, increased competition from within the O&G industry leads to increased focus on improving the sustainability of supply chain functions. On the other hand, increased competition from the broader energy industry causes companies to reduce their focus on the sustainability of strategic supply chain management areas. These results demonstrate that companies in the O&G industry are aware of the pressure that the external factors exert on them and adjust their responses accordingly. Their main priority will be on remaining competitive, even at the expense of their environmental and social performance.
- Concerning internal factors, we found that management preparedness has a strong relationship with all supply chain functions, except production management. We attributed this finding to the inflexibility of O&G infrastructures as well as the high costs needed to improve the sustainability of the production processes involved in O&G development. Therefore, companies in the O&G industry may give more priority to sustainability strategies of supply chain functions that do not require major technological changes. This includes strategies related to, for example, acquisition of raw materials, product life-cycle, and distribution practices. Increased management preparedness in improving the sustainability of these supply chain areas could help companies to reduce the negative impacts associated with production activities.

Overall, insights gained from the studies conducted are able to shed some lights on the contextual factors that can affect the implementation of SSCM practices in the O&G industry. In addition, the studies allow us to identify the strategies that companies in the industry used to integrate sustainable practices in the management of their supply chains.

7.3 Managerial implications

Several managerial implications can be derived from the findings of our studies. First, the framework that we proposed can be used by O&G companies to assess their contextual environment. Specifically, it can be used as a tool in decision-making processes to improve supply chain sustainability through: (1) an analysis of the key business and organizational factors that can play a role on SSCM practices; and (2) the development of more effective supply chain management measures and capabilities.

Second, our findings show the importance of developing internal capabilities and resources (or adjusting organizational routines and practices) that can address external pressure for more sustainable practices, particularly from stakeholders. Companies must employ proactive stakeholder engagement strategy by identifying stakeholder groups that can affect or be affected by companies' activities as well as their expectations and concerns early on in a project. This would enable them to determine an appropriate line of responses that can be used to develop better SSCM strategies. It would also help reduce the risks related to inadequate stakeholder engagement practices.

Third, we find that there is a negative relationship between competition from broader energy industry (e.g. from alternative energy companies) and strategic sustainability goals, while energy transition has a positive relationship with the goals. These findings should change the view that O&G and its alternatives are competing, into one that is more of complementarity. The involvement of O&G companies in the development of alternative cleaner and renewable energy, for example, can help green their supply chains and facilitate their transition to a low carbon energy future. While it may seem to be financially advantageous to address competition from alternative energy on a commercial basis, the O&G industry cannot really afford to ignore the competition for long, as demonstrated by the recent climate and carbon emissions agreements reached at the recent 2015 United National Climate Change Conference (COP21) in Paris. The O&G industry must be able to integrate sustainable energy technologies in its supply chain management in order to address the pressures. Therefore, managers can monitor the progress of alternative energy to identify viable business opportunities as well as advances in energy technologies that can be integrated into their existing infrastructure and capabilities.

Fourth, the external factors are to a large extent beyond company control. This can increase the contextual uncertainties of their supply chains. In order to overcome this lack of control, managers must develop organizational culture and management preparedness capabilities that can facilitate their adoption of SSCM practices to address the external pressure. Our findings suggest that management of supply chain operational risks is important to SSCM implementation. For example, the risks related to regulatory requirements, SHE risks of supply chain activities, stakeholders expectations, as well as business conduct of suppliers related to environmental and social protection. Companies should, therefore, implement risk management strategy that facilitate the implementation of: (a) supply management practices that emphasize responsible business conduct of suppliers and preference for environment-friendly source materials, (b) proactive management of the impact of processes and products throughout their life-cycle, and (c) logistics solutions that are efficient, safe and environment-friendly. In addition, companies can create synergies between different supply chain functional areas, especially between supplier management, product stewardship and logistics management functions. Increase collaboration with supply chain partners through sharing of expertise and resources as well as shared responsibilities for supply chain performance can also facilitate the implementation of SSCM practices. This is to ensure that sustainable practices can be integrated beyond organizational boundaries to include the practices of all supply chain partners towards achieving the chains' sustainability goals.

Finally, companies in the O&G industry must improve the extensiveness of their performance management practices. This is to enable a more transparent communication of their commitment to sustainability and progress in sustainable supply chain practices. Besides helping companies to make informed supply chain decisions and strategies, it can also help in facilitating companies' engagement with stakeholders. Companies should also improve their sustainability reporting practices to exploit the strategic importance of public disclosure of commitments and performance in sustainability areas to enhance their corporate and social legitimacy.

Overall, the findings of this study can be used by managers of companies in the O&G industry to plan and design SSCM strategies. This can help the companies address the pressures for more environmentally and socially responsible activities in their supply chains.

7.4 Recommendations for future research

The sustainability of O&G supply chain management practices is an important research area that deserves more attention than it currently receives. This thesis contributes to the discussions on this topic by examining the contextual factors of SSCM practices in the O&G industry. Further research in these areas would help us increase our understanding regarding SSCM practices in the O&G industry and the challenges that companies face in their implementation of the practices. Based on the findings of this thesis, we are able to identify several opportunities for further research.

First, in our analyses of the external factors of O&G industry we discovered interesting findings regarding the influence of different types of competition on strategic and functional supply chain sustainability goals. We find that companies' responses vary depending on the sources of competition, and it appears that the focus on strategic sustainability goals will be reduced under increased competition from broader energy industry players (for example, renewable energy companies). We assumed that companies would compete with the players in commercial areas (price and cost) rather than through improvements in the sustainability of their practices to remain competitive. However, further research is needed to validate this assumption. In addition, researchers could identify the mechanisms that can be used by companies to address the competition pressure that can result in "sustainable compromise" between economic, environmental and social goals. Another interesting area that could be examined is how the differences in companies' operating context, e.g. countries, company ownership, types of operations etc., could determine their competition strategies as they strive to improve the sustainability of their SSCM practices.

Second, the influence of energy transition on O&G supply chain sustainability is an interesting topic that warrants further investigation. We find that increased policy support to spur the transition to sustainable energy systems can lead to a higher focus on strategic sustainability goals. We think that companies in the O&G industry may be benefiting from the policy supports to start their own alternative energy project and build their expertise in this area (Roy et al., 2013), thus the increase of strategic goals. If this is the case, studies should be conducted to identify the motivation behind this move, the types of alternative energy technologies that are being developed, and the extent of their involvement. Since the characteristics and supply bases of alternative energy sources are different than O&G, studies can also be done to understand how these factors can influence companies' supply chain strategies and design, as well as the sustainability of their supply chain practices. In addition, researchers can focus on understanding how companies can create synergies between their existing business (areas of expertise) and new business opportunities in renewable and low carbon energy development. This will allow us to understand how to exploit the

complementary benefits of the synergies to improve the sustainability of supply chain management practices.

Third, this thesis examined the relationship between internal organizational factors and sustainable supply chain strategies. The investigation of this relationship can be extended into identifying how the strategies can influence supply chain sustainability performance. Our analysis of survey data revealed that the extensiveness of performance management practices in the O&G industry is at a moderate level, probably due to the complexity of its supply chain activities and actors involved. Therefore, studies can also be conducted to identify the challenges that companies face in measuring supply chain performance and the strategies that can be used to address the challenges.

Fourth, another opportunity for additional research concerns the distinction between upstream and downstream companies (including level of integration of O&G operations), types of ownership (e.g. public and private, OPEC and non-OPEC), and operating countries context (e.g. developed and developing). For example, the effect of the external and internal factors on supply chain sustainability strategies may be different upstream where companies have to deal more with risks related to ownership and access to reserves compared to downstream companies, which deal with supply and consumer related risks. In addition, companies operating in multiple countries may need to deal with the countries' different regulatory requirements, development needs, culture and technological capabilities. These factors could affect the SSCM strategies that can be implemented.

Our survey did not allow us to reach separate conclusions for companies that operate in these different operating contexts. A sampling strategy that can distinguish these companies and their operating context could help in determining the differences in their SSCM strategies. Similarly, it will be very interesting if we could map the SSCM practices of companies along the O&G supply chain, i.e. by using supply chain as a unit of analysis instead of company, and identify how the strategies are influenced by their internal and external contextual environments. This will allow us to increase our understanding of the O&G industry's responses to internal and external sustainability pressures in its supply chain. In addition, the findings can be used to formulate SSCM strategies that are tailored to the different stages of the upstream and downstream O&G supply chain operating requirements, types of company ownership, as well as country context. Methodologically, case or longitudinal studies are better suited for this purpose as these approaches allow a more comprehensive investigation compared to cross-sectional surveys. For example, through case studies researchers could examine companies policy documents and reports related to sustainable practices, conduct interviews with managers, employees as well as suppliers, and observe day-to-day activities related to supply chain management.

Fifth, we discussed the linkages of the conceptual framework of this thesis to three organizational theories in Chapter 2. The theories are institutional theory, stakeholder theory and dynamic capabilities theory. The assumptions of these theories, however, are not tested in this thesis. Therefore, researchers could conduct a survey or case study to test and explain the relationships between contextual factors and SSCM based on the theories. This could help further validate the framework proposed.

Finally, in this thesis we do not test all of the relationships proposed in the conceptual framework. Future studies, therefore, can focus on testing more complex relationships between contextual factors (internal and external) and sustainable supply chain strategies. First, researchers can examine the role of supply chain sustainability goals in mediating the relationship between external business environment factors, and companies' commitment to sustainability and management preparedness. Second, they can also identify how the goals can influence the extent of companies' commitment to and preparedness for SSCM implementation. Last, further studies can be conducted to understand how commitment and

preparedness moderate the relationship between supply chain sustainability goals and supply chain sustainability strategies.

7.5 Concluding remarks

This thesis examined the contextual factors within the O&G industry's external business environment and internal organizational environment that can influence its adoption of SSCM practices. It argues that companies in the industry will implement sustainable supply chain strategies that are able to align their internal environment with the pressure exerted by factors in the external environment in order to achieve the companies' supply chain sustainability goals. SSCM strategy is, therefore, an outcome of the interplay between factors within organizational and business environments, as well as companies' interaction with the environments. We believe that our studies are able to shed some light on this notion, specifically in the context of the O&G industry's supply chain practices.

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Summary

Oil and gas (O&G) are deeply entrenched in our lives, to a point that if we look around us now we will see that these natural resources play some crucial roles in enabling us to conduct our daily activities. From transport, heating and lights right to the things we consume or use every day, O&G are somehow part of the elements that make every progress in modern society possible. However, these advantages come at great expense on the environment due to the activities involved in developing, refining and transporting O&G products. Increased public awareness regarding the negative impacts of the activities creates pressures for the O&G industry to improve the sustainability of its supply chain management practices.

The O&G industry supply chain is characterized by highly complex networks of companies that operate in environments that transcend political, economic and cultural boundaries. A review of literature related to sustainable supply chain management (SSCM) reveals that there is a lack of SSCM research in the O&G industry context. This is surprising if we consider the central importance of O&G to supply chain management of all industrial and economic activities. This thesis addresses this gap by focusing on *understanding the contextual factors of SSCM practices in the industry*. Specifically, it explores the influence of the contextual factors within the O&G industry external business environment and internal organizational environment on its implementation of sustainable supply chain strategies. This thesis argues that every company or industry operates within unique business and organizational environments, and companies' interactions with these environments determine their SSCM strategies. Understanding these environments allows us to identify the contextual factors that can drive or hinder the adoption of sustainable supply chain strategies among the companies that operate in the O&G industry.

In the introduction chapter, this thesis poses five research questions which are as follows:

RQ1: What are the factors within the O&G industry's external business environment and internal organizational environment that can influence its implementation of SSCM practices?

RQ2: What are the sustainable supply chain strategies adopted by companies in the O&G industry?

RQ3: To what extent do companies in the O&G industry communicate their commitment and performance related to sustainable practices?
RQ4: What are the most important external factors that can influence its adoption of SSCM practices?
RQ5: What are the relationships between the external and internal factors with sustainable supply chain strategies?

Several studies and analyses are conducted to answer the questions and achieve the main objective of this thesis. For the research question, "***what are the factors within the O&G industry's external business environment and internal organizational environment that can influence its implementation of SSCM practices?***", a literature review was conducted to identify the factors. The results are presented in Chapter 2. Using the PESTEL model (i.e. political, economic, social, technological, environment and legal factor) as a basis for understanding a firm's external macro-environment, this thesis reviews the O&G supply chain and the SSCM literature to examine the O&G industry's external operating context. Based on the review, six factors that are relevant to our study and the O&G industry context are chose for further investigation, namely: political stability, economic stability, stakeholder pressure, competition, energy transition and regulations. The review also revealed that the internal organizational contextual factors that can influence SSCM practices can be grouped into sustainability goals, commitment to sustainability (i.e. top management leadership, organizational culture and transparency), management preparedness (i.e. risk management, cross-functional integration and performance management), and sustainability strategies of supply chain functions. Based on the literature review, we proposed a conceptual framework of SSCM practices in the O&G industry, as illustrated in Figure 1.

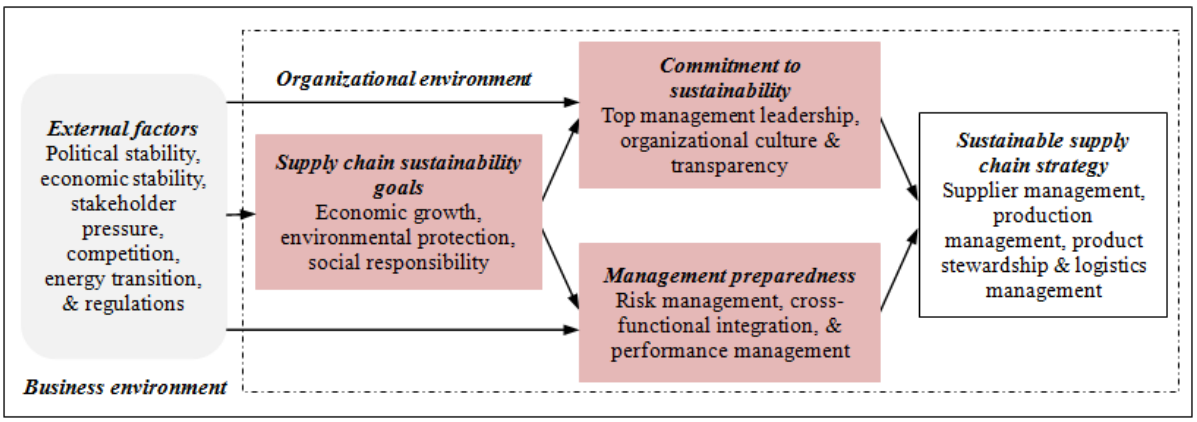


Figure S1 – Conceptual framework of SSCM of O&G

This conceptual framework has linkages to three complementary organizational theories namely institutional theory, stakeholder theory and dynamic capabilities. Specifically, institutional theory and stakeholder theory describe how the external business environment factors can influence companies' actions and strategies related to SSCM practices. Dynamic capabilities theory, on the other hand, explains how internal organizational factors (i.e. resources and capabilities) can facilitate the implementation of SSCM practices in the companies. These external and internal factors are further examined through surveys.

In Chapter 3, this thesis focuses on gaining an overview of how sustainable practices are addressed by companies in the O&G industry. Specifically, a content analysis of sustainability reports of 30 O&G companies was conducted to answer, *"**to what extent do companies in the O&G industry communicate their commitment and performance related to sustainable practices?**"* The analysis reveals that the companies expressed higher intent for environmental

sustainability compared to social sustainability, but their disclosure of social performance is higher than environmental performance. This shows that there was an inconsistency in the reporting of their sustainable practices. The companies, in general, had clear policies with regard to their commitment and plans for environmentally and socially responsible practices. However, they must also be able to translate the policies into real actions that can be used to measure progress and to identify improvement opportunities as well as areas of priorities so as to improve the sustainability of the practices. Our analysis of the sustainability reports indicates that the reporting of this area can be improved, i.e. the actual steps taken to address sustainability issues and their corresponding performance measures.

This thesis also examines how sustainability was integrated into O&G companies' supply chain practices through the content analysis. The research question here is: *"**what are the sustainable supply chain strategies adopted by companies in the O&G industry?**"* The same research question was also used in the literature review stage. The analysis shows that the reporting of this aspect among the companies differs greatly. The reports as a whole, however, enable us to gain an overview of their SSCM strategies, specifically in terms of supplier management, product stewardship and logistics management. The discussions on the strategies were focused on supplier selection and monitoring practices based on environmental and social criteria, local content strategy as well as evaluation and communication of safety, health and environmental (SHE) risks of products during production, storage and transportation processes. While the reports enable us to learn about the companies' SSCM strategies, the discussions on the performance or the outcomes of the strategies implementation were notably weak. Perhaps the lack of supply chain related indicators in sustainability reporting guidelines used by the companies contribute to these findings. Overall, it is apparent that significant improvements are needed in the companies' discussions and disclosure regarding the sustainability of their supply chain practices.

Chapter 4 focuses on understanding *"**what are the most important external factors that can influence the O&G industry's adoption of SSCM practices?**"* There are a lot of studies on the external factors that can influence the industry operations such as economic and geopolitical condition, as well as regulations. However, there is a lack of understanding on which factors are the most important to its SSCM practices. We conducted a survey among experts in supply chain management and the O&G field to answer this question. Data gathered were analyzed using the Best Worst Method (BWM), which is a new multi-criteria decision making (MCDM) method. The analysis indicates that economic stability is by far the most important factor, followed by competition, political stability, and stakeholder pressure. Regulations and energy transition are the two least important factors that can influence SSCM practices in the O&G industry.

The finding that energy transition is the list important factor can be attributed to the slow progress of alternative energy growth and diffusion in the current energy systems. Specifically, the experts may have perceived that, compared to other external factors, the current pace of energy transition creates little pressure for the O&G industry to improve the sustainability of their supply chains. The finding that regulations are among the least important external factor, however, is rather surprising because the factor is often cited in the literature as an important driver to SSCM practices. This can indicate that a more competitive market and greater stakeholder pressure would force companies to improve supply chain sustainability, even during the absence of regulatory pressure. Stable economic and political conditions could facilitate such improvement, as it would provide a more conducive environment for companies to focus their resources on operational issues related to supply chain sustainability.

The final research question of this thesis is: *"**what are the relationships between the external and internal factors with sustainable supply chain strategies?**"*, which is discussed

in Chapter 5 and Chapter 6. Specifically, Chapter 5 focuses on the external factors with regard to their influence on supply chain sustainability goals. It argues that companies' responses to external environment will determine their commitment to and preparedness for sustainable practices, and eventually the supply chain strategies adopted by the companies. Chapter 6 discusses the relationships between these internal factors (i.e. commitment to sustainability and management preparedness) and the eventual strategies. The results presented enable more detailed discussions of the relationships between the factors proposed in the conceptual framework of this thesis. Data for this study were gathered through a survey among companies that operate along the upstream and downstream O&G supply chain. They were analysed using factor analysis, correlation analysis and multiple regression analysis.

The factor analysis indicates that there are two categories of supply chain sustainability goals, namely strategic sustainability goals (important for long-term survival) and functional sustainability goals (related to supply chain operational processes). Multiple regression analysis reveals that stakeholder pressure has the strongest relationship with the strategic and functional goals. Apart from stakeholder pressure, economic stability also has a positive relationship with the goals. Energy transition, on the other hand, can only lead to increased focus on strategic sustainability goals. The analysis also shows that when companies experience fewer political conflicts related to societal sources in their business environment, they will be able to focus more on SHE management (one of the strategic sustainability goals).

It is interesting to discover that competition can both drive and hinder companies' focus on sustainable practices. Specifically, while increased competition from the broader energy industry can reduce companies' focus on strategic sustainability goals, increased competition from within the O&G industry itself can lead to higher focus on functional sustainability goals. Similar findings were obtained for the relationship between regulations and individual sustainability goals. The analysis reveals that increased regulatory pressure can drive companies to focus more on SHE management. However, the regulatory factor has a negative effect on the energy security. These findings show companies' interest-seeking nature and further emphasize that their responses to external pressure vary depending on its context.

In terms of the influence of commitment to sustainability and management preparedness on sustainable supply chain strategies, this thesis discovers that both factors can enhance companies' adoption of the strategies. Management preparedness, however, is more important than commitment in influencing the extent of the strategies implementation. These findings indicate that commitment alone is insufficient in driving the introduction and the adoption of SSCM practices in the O&G industry. Instead, companies in the industry must equip themselves with appropriate resources and competences that can turn the commitment into strategies and actions to produce actual results that can improve supply chain sustainability.

Among commitment to sustainability measurement items, regression analysis reveals that organizations that are ingrained with culture that promote, for example, open communication, proactiveness, innovation and risk taking behaviour are more likely to implement sustainable supply chain practices, especially in production management and product stewardship. For the management preparedness factor, while cross-functional integration and performance can enhance companies' SSCM implementation, risk management appears to be the most important factor to the implementation. This thesis also discovers that supplier management and logistics management are the only supply chain functions that can be influenced by different management preparedness factors. This can signify the importance of these functions to SSCM practices due to their central role in acquisition and distribution activities in supply chain. Overall, the analyses emphasize the importance of creating synergies between different supply chain functional areas through development of internal commitment and preparedness that can facilitate the adoption of SSCM practices in the O&G industry.

Chapter 7 concludes this thesis with the discussion on the main findings, its implications as well as some recommendations for future SSCM studies in the O&G context. The discussions on the managerial implications of this thesis focus on the development of organizational culture, performance management as well as internal resources and competences that can help companies address external pressure and facilitate the implementation of SSCM strategies. This thesis proposes that future research can focus on furthering our understanding regarding how competition from different groups of energy players and energy transition can influence the sustainability of the O&G supply chain management practices. In addition, the study of the relationship between internal organizational factors and sustainable supply chain strategies can be extended to also include their related performance aspects. The practical application of SSCM practices to the O&G industry can also be enhanced if researchers are able to distinguish and map: (1) the SSCM strategies adopted by companies that operate in different O&G supply chain stages (i.e. along the upstream and downstream supply chain), and (2) the external and internal challenges that the companies face in implementing the strategies.

As a conclusion, this thesis argues that the SSCM strategies adopted by companies in the O&G industry resulted from their responses to the interplay between the factors within their external business environment and internal organizational environment. The findings of the studies conducted in this thesis shed some lights on this notion. They can be used to enhance our understanding of SSCM practices in the O&G industry and improve its future implementation of the practices.

Samenvatting

Olie en gas (O&G) zijn diep in ons leven doorgedrongen. Als we om ons heen kijken zien we dat deze natuurlijke hulpbronnen een cruciale rol spelen in het mogelijk maken van allerlei activiteiten en diensten zoals transport, verwarming en verlichting. De voordelen van O&G gaan echter gepaard met milieukosten als gevolg van het ontwikkelen, raffineren en transporteren van O&G-producten. Het toegenomen publieke bewustzijn over de negatieve gevolgen van O&G-gebruik zorgt voor druk in de O&G-industrie om de duurzaamheid van haar toeleveringsketen te verbeteren.

De toeleveringsketen van de O&G-industrie wordt gekarakteriseerd door zeer ingewikkelde netwerken van bedrijven die opereren in omstandigheden die politieke, economische en culture grenzen overstijgen. Een review van de literatuur over duurzaam management van de voortbrengings- en toeleveringsketen ('sustainable supply chain management', vanaf nu afgekort tot SSCM) laat zien dat er een tekort is aan SSCM-onderzoek gericht op de O&G-industrie. Deze thesis adresseert dit tekort door te focussen op het begrijpen van de contextuele factoren voor het toepassen van SSCM in de O&G-industrie. Deze thesis verkent de invloed van contextuele factoren in de externe zakelijke omgeving van de O&G- industrie en van contextuele factoren in haar interne organisatie op implementatie van SSCM-strategieën. De thesis beargumenteert dat elk bedrijf of industrie binnen een unieke zakelijke en organisatorische omgeving opereert, en dat de interacties van dit bedrijf met deze omgevingen zijn SSCM-strategie bepaalt. Het begrijpen van de externe en interne omgevingen maakt het mogelijk de contextuele factoren te identificeren die adoptie van SSCM-strategieën mogelijk maken (of juist verhinderen) door bedrijven die opereren in de O&G-industrie.

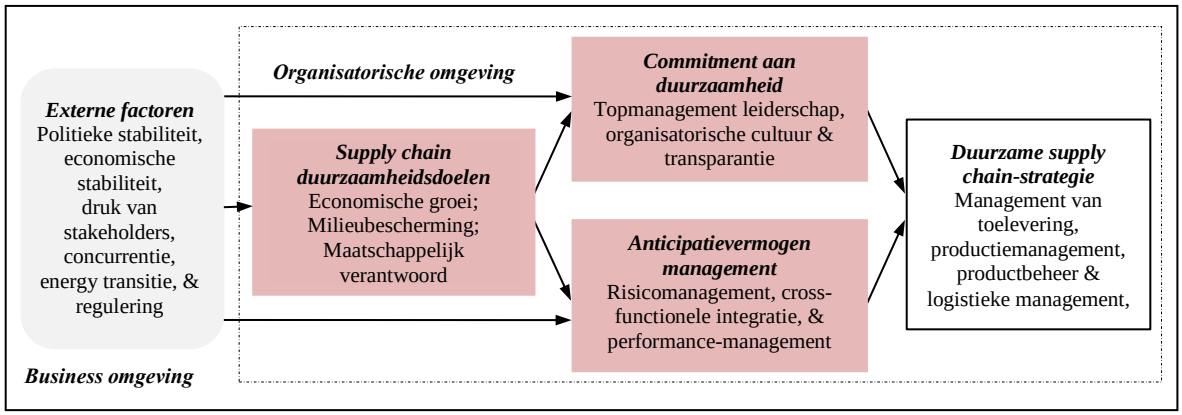
Vijf onderzoeksvragen staan centraal in deze thesis:

RQ1: Wat zijn interne en externe factoren in de business van de O&G-industrie en in de organisatorische omgeving van de O&G-industrie die adoptie van SSCM-toepassingen kunnen beïnvloeden?

RQ2: Welke SSCM-strategieën zijn door bedrijven in de O&G-industrie geadopteerd?

RQ3: In welke mate communiceren bedrijven in de O&G-industrie hun commitment en prestaties op het vlak van duurzaamheid?
RQ4: Wat zijn de belangrijkste externe factoren die adoptie van SSCM-toepassingen kunnen beïnvloeden?
RQ5: Wat zijn de relaties tussen externe en interne factoren en SSCM-strategieën?

Verscheidene kwalitatieve studies en kwantitative analyses zijn uitgevoerd om deze vragen te beantwoorden. Voor de vraag, '***Wat zijn interne en externe factoren in de business van de O&G-industrie en in de organisatorische omgeving van de O&G-industrie die adoptie van SSCM-toepassingen kunnen beïnvloeden?'***, is een literatuurreview uitgevoerd. De resultaten staan weergegeven in hoofdstuk 2. Het zogenaamde PESTEL-model (Politiek, Economisch, Maatschappelijk ('Social'), Technologisch, Milieu ('Environment') en wettelijke ('Legal') is in de review gebruikt als uitgangspunt om relevante externe macrofactoren te identificeren in de omgeving van bedrijven in de O&G-industrie. Zes relevante factoren zijn gekozen voor nader onderzoek, namelijk: politieke stabiliteit, economische stabiliteit, druk van stakeholders, concurrentie, energietransities en regulering. Interne organisatorische contextuele factoren die SSCM-toepassing kunnen beïnvloeden kunnen volgens de review gecategoriseerd worden in duurzaamheidsdoelen, commitment aan duurzaamheid (gerelateerd aan leiderschap van het topmanagement, cultuur binnen de organisatie en transparantie), anticipatievermogen van het management (gerelateerd aan risicomanagement, cross-functionele integratie en performance- management), en duurzaamheidsstrategieën van functies in de toeleveringsketen. We stellen op basis van de review het volgende conceptuele framework voor van de praktijk van SSCM in de O&G-industrie, Figuur 1.



Figuur S1 – Conceptueel framework van SSCM in O&G

Dit conceptuele raamwerk heeft verbanden met drie complementaire organisatietheorieën, namelijk institutionele theorie, stakeholdertheorie en de theorie van dynamische bekwaamheden. Institutionele en stakeholdertheorie beschrijven hoe factoren in de externe business-omgeving SSCM-toepassingen en – strategieën beïnvloeden. De theorie van dynamische bekwaamheden verklaart hoe interne organisatorische factoren implementatie van SSCM-praktijken kunnen ondersteunen. Met enquêtes zijn deze externe en interne factoren verder onderzocht.

Hoofdstuk 3 richt zich op het verwerven van inzicht hoe bedrijven in de O&G-industrie duurzaamheid invullen. De duurzaamheidsrapporten van 30 O&G-bedrijven zijn inhoudelijk geanalyseerd om antwoord te geven op vraag '***Welke SSCM-strategieën zijn door bedrijven in de O&G-industrie geadopteerd?'***. De inhoudelijke analyse laat zien dat bedrijven enerzijds aangeven dat ze milieugerichte duurzaamheid belangrijker vinden dan sociale duurzaamheid. Tegelijk geven ze in hun rapporten meer aandacht aan hun sociale- dan aan hun

milieuprestaties. Ze zijn inconsistent in het rapporteren van hun duurzaamheidsgedrag. In zijn algemeenheid rapporteren bedrijven duidelijk over hun commitment en plannen voor duurzaamheid. Ze moeten echter hun beleid ook vertalen in concrete acties die meetbaar zijn en in verbeteringsmogelijkheden en prioriteiten richting meer duurzaamheid. Onze analyse laat zien dat de rapportages op deze vlakken verbeterd kunnen worden, dat wil zeggen, op het vlak van concrete stappen richting duurzaamheid en de daarmee samenhangende prestatie-eisen.

Deze thesis onderzoekt met dezelfde inhoudelijke analyse ook hoe duurzaamheid is geïntegreerd in *supply chain management*-praktijken van O&G-bedrijven. De onderzoeksvraag hierbij is '***In welke mate communiceren bedrijven in de O&G-industrie hun commitment en prestaties op het vlak van duurzaamheid?***'. De analyse toont aan dat bedrijven in grote mate verschillen in het rapporteren over deze aspecten. Alle rapporten gezamenlijk stellen ons in staat overzicht te krijgen in hun SSCM-strategieën in termen van 'management van toeleveranciers', productbeheer en logistieke management. De teksten over deze strategieën richten zich op toeleverancierskeuzen, monitoringspraktijken gebaseerd op milieu- en maatschappelijke criteria en inhoudelijke lokale strategieën. Ook richten deze strategieën zich op evaluatie van en communicatie over veiligheids-, gezondheids- en milieurisico's van producten gedurende productie, opslag en transport. Terwijl de rapporten ons in staat stellen om te leren over de SSCM-strategieën van bedrijven, zijn ze opmerkelijk zwak in discussies over de prestaties van geïmplementeerde strategieën. Mogelijk is dit resultaat een gevolg van een gebrek aan prestatie-indicatoren in de richtlijnen voor duurzaamheidsrapportage. Hoe dan ook: het lijkt duidelijk dat belangrijke verbeteringen nodig zijn in het rapporteren over en in de openbaarmaking van duurzaamheid in toeleveringsketens van O&G-bedrijven.

Hoofdstuk 4 richt zich op het beantwoorden van de vraag '***Wat zijn de belangrijkste externe factoren die adoptie van SSCM-toepassingen kunnen beïnvloeden?***' Er zijn veel studies over externe factoren die de manier van werken van de industrie kunnen beïnvloeden zoals economische en geopolitieke factoren alsmede regulering. Het is echter niet bekend welke factoren het belangrijkst zijn in de praktijk van SSCM. We hielden een enquête onder experts in ketenmanagement in de O&G-industrie om de vraag te beantwoorden. De verzamelde data is geanalyseerd met de zgn. *Best Worst Method*, een nieuwe methode in de familie van multicriteria-beslissingsmethoden. De analyse wijst uit dat economische stabiliteit verreweg de belangrijkste factor is, gevolgd door concurrentie, politieke stabiliteit, en druk van stakeholders. Regulering en energietransitie zijn de minst belangrijke factoren die SSCM-praktijken in de O&G-industrie kunnen beïnvloeden.

De langzame diffusie en groei van alternatieve energie in het huidige energiesysteem zouden hiermee te maken kunnen hebben. De experts zouden kunnen denken dat, vergeleken met de andere externe factoren, de huidige snelheid van energietransitie geen druk creëert op de O&G-industrie om haar toeleveringsketen duurzamer te maken. Het is echter wel verrassend dat regulering door de experts als minst belangrijke factor wordt gezien want in de literatuur wordt deze factor vaak aangemerkt als een belangrijke determinant voor de SSCM praktijk. Dit zou er ook op kunnen duiden dat een concurrerendere markt en een toenemende druk van stakeholders bedrijven dwingt tot een duurzamere toeleveringsketen, zelfs als er geen druk is vanuit regulering. Stabiele economische en politieke omstandigheden zouden een dergelijke verbetering kunnen faciliteren; deze maken het immers eenvoudiger om hulpbronnen te richten op operationele kwesties gerelateerd aan SSCM.

De laatste vraag is '***Wat zijn de relaties tussen externe en interne factoren in SSCM-strategieën?***' en wordt bediscussieerd in hoofdstuk 5 en hoofdstuk 6. Hoofdstuk 5 richt zich op de externe factoren die van invloed zijn op doelen in een duurzame toeleveringsketen. We beargumenteren in dit hoofdstuk dat reacties van bedrijven op de externe omgeving hun

commitment en bereidheid bepalen voor duurzame praktijken, en uiteindelijk op hun *supply chain management* strategieën. Hoofdstuk 6 gaat in op de relaties tussen deze interne factoren (commitment aan duurzaamheid en bereidheid van het management) en de eventuele strategieën. De gepresenteerde resultaten maken een gedetailleerde discussie mogelijk van de factoren zoals weergegeven in het conceptuele raamwerk van deze thesis. De data voor deze studie zijn verzameld met een enquête bij bedrijven die boven- en benedenstrooms in de toeleveringsketen van de O&G-industrie opereren. De data zijn geanalyseerd met factoranalyse, correlatieanalyse en multivariate regressieanalyse.

De factoranalyse wijst uit dat er twee categorieën van duurzaamheidsdoelen in toeleveringsketens zijn, namelijk strategische duurzaamheidsdoelen (belangrijk voor langetermijnoverleving) en functionele duurzaamheidsdoelen (gerelateerd aan operationele processen in toeleveringsketens). Multivariate regressieanalyse wijst uit dat druk van stakeholders de sterkste relatie heeft met strategische en functionele doelen. Naast deze druk van stakeholders heeft ook economische stabiliteit een positieve relatie met de doelen. Energietransitie, aan de andere kant, kan alleen leiden tot een toenemende focus op strategische duurzaamheidsdoelen. De analyse laat ook zien dat wanneer bedrijven weinig politieke conflicten in hun handelsomgeving ervaren, dat ze dan meer in staat zijn te focussen op SHE *(Safety, Health en Environment)* management, één van de strategische duurzaamheidsdoelen.

Het is interessant te ontdekken dat concurrentie zowel de focus van bedrijven op duurzame handelen kan stimuleren als bemoeilijken. Specifieker gesteld, terwijl meer concurrentie van de bredere energie-industrie de focus van bedrijven op strategische duurzaamheidsdoelen kan verminderen, kan juist meer concurrentie binnen de O&G-industrie leiden tot een toenemende focus op functionele duurzaamheidsdoelen. Gelijksoortige resultaten werden gevonden bij de relatie tussen regulering en individuele duurzaamheidsdoelen. De analyse laat zoals verwacht zien dat toenemende regulering bedrijven kan bewegen zich meer te richten op SHE management. Maar de factor regulering heeft een negatief effect op energievoorzieningszekerheid. De resultaten laten de aard van bedrijven zien om hun eigen belang na te streven. Verder benadrukken de resultaten dat reacties van bedrijven op externe druk variëren afhankelijk van de context.

In termen van invloed van de factoren ‘commitment aan duurzaamheid’ en ‘managementbereidheid richting een duurzamere toeleveringsketen’, toont deze thesis aan dat beide factoren de adoptie van duurzaamheidsstrategieën door bedrijven kunnen versterken. Managementbereidheid is echter belangrijker dan commitment voor de mate waarin strategieën worden geïmplementeerd. Deze resultaten wijzen uit dat commitment alleen onvoldoende is om SSCM-toepassingen aan te zwengelen en te laten landen in de O&G-industrie. Bedrijven in deze industrie moeten zich ook uitrusten met geschikte hulpmiddelen en competenties die de commitment kunnen omzetten in strategieën en acties die werkelijk resultaat kunnen boeken.

De regressieanalyse met variabelen die iets zeggen over commitment aan duurzaamheid toont aan dat organisaties die doordrongen zijn van een cultuur die nadruk legt op bijvoorbeeld open communicatie, proactief gedrag, en bereidheid tot het nemen van risico’s waarschijnlijk als eerste een duurzamere toeleveringsketen implementeren, vooral gerelateerd aan zaken als productiemanagement en productbeheer. Voor factoren gerelateerd aan ‘bereidheid van het management’ blijkt bereidheid tot het nemen van risico’s de belangrijkste factor om implementatie van SSCM te versterken en spelen cross-functionele integratie en performance daarbij een minder belangrijke rol. De analyse leidt ook tot de bevinding dat ‘management van toeleveranciers’ en ‘logistieke management’ de enige functies in de toeleveringsketen zijn die beïnvloed kunnen worden door verschillende factoren gerelateerd aan ‘bereidheid van het management’. Dit kan het belang van deze functies aangeven in de

praktijk van SSCM vanwege hun centrale rol in activiteiten in de toeleveringsketen gerelateerd aan het verwerven en distribueren van goederen. Alles bijeen genomen benadrukken deze analyses het belang van het creëren van synergie tussen verschillende functies in de toeleveringsketen door het ontwikkelen van interne 'commitment' en 'bereidheid' die de adoptie van SSCM-toepassingen in de O&G-industrie kunnen faciliteren..

In hoofdstuk 7 worden de belangrijkste bevindingen, de implicaties en een aantal aanbevelingen voor verder onderzoek besproken. De discussie over implicaties voor *supply chain management* richt zich op het ontwikkelen van een organisatiecultuur en van prestatiebeheersing, alsmede op het ontwikkelen van interne hulpmiddelen en competenties die bedrijven kunnen ondersteunen in het omgaan met externe druk bij het faciliteren van de implementatie van SSCM-strategieën. Deze thesis stelt voor dat toekomstig onderzoek zich kan richten op het verder begrijpen hoe concurrentie van diverse spelers op de energiemarkt en energietransitie de duurzaamheid van de managementpraktijk van toeleveringsketens in de O&G-industrie kunnen beïnvloeden. Daarnaast kan de studie naar de relaties tussen interne organisatorische factoren en SSCM-strategieën uitgebreid worden, zodat ook daadwerkelijke prestaties in ogenschouw worden genomen. De toepassing van SSCM in de O&G-industrie zou ook versterkt kunnen worden indien onderzoek in staat zou zijn de volgende twee aspecten te onderscheiden en in kaart te brengen: (1) de SSCM- strategieën die zijn geadopteerd door bedrijven die werkzaam in verschillende fasen van de toeleveringsketen in de O&G (dat wil zeggen boven- en benedenstrooms in de toeleveringsketen), en (2) de externe en interne uitdagingen waarmee bedrijven worden geconfronteerd wanneer ze duurzame strategieën willen implementeren.

De conclusie van deze thesis is dat SSCM-strategieën die zijn geadopteerd door de O&G-industrie het resultaat zijn van een samenspel tussen externe 'business'-factoren en de interne organisatorische omgeving. De resultaten van de studies die in deze thesis zijn uitgevoerd werpen nieuw licht op deze notie. De resultaten kunnen worden gebruikt om de praktijk van SSCM in de O&G-industrie beter te begrijpen en om de toekomstige implementatie van deze praktijk verder te versterken.

Appendix I

Indicators used in content analysis based on Pacific Sustainability Index

Table Ia – Environmental sustainability indicators

Dimensions		Elements	Keywords/ location
Environmental Intent	Accountability	Report contact person	Usually provided at the end of report
		Environmental management structure	Management approach, governance, committee (usually at 'How we operate' section
	Management	Environmental education	Education, training, workshop, course(s)
		Environmental management system	Environmental management systems
		Environmental accounting	Environmental accounting, expenditure
		Stakeholder consultation	Stakeholder consultation, stakeholder engagement, stakeholders
	Policy	Environmental **policy** statement	Usually located at vision/mission statement, management approach, values statement
		Climate change/ global warming	Climate change, global warming
		Habitat/ ecosystem conservation	Habitat, ecosystems
		Biodiversity	Biodiversity
		Green purchasing	Green purchasing, procurement, sourcing
	Vision	Environmental impediments and challenges	Environmental impediments/challenges/difficulty /burden/ restriction
		Environmental **visionary** statement	Usually located at vision/mission statement, management approach, values statement
Environmental Reporting	Emissions to air	GHG (or CO2 equivalents), total	Refer to performance data
		CO2 or equivalents (i.e. GHG)	
		Volatile organic compounds (VOCs)	
		Methane (CH4)	
		Sulfur hexafluoride (SF6)	
		Carbon monoxide (CO)	
		Nitrogen oxides (NOx)	
		VOC concentration	
		Particulate matter (dust)	
		Sulfur oxides (SOx)	
	Emissions to water	Suspended solids, total (TSS)	Refer to performance data
		Biochemical oxygen demand (BOD)	
		Emissions to water, total, including fuel spillage or leakage	
	Energy	Energy used (total)	Refer to performance data
		Energy used (renewable)	
	Management	Notices of violation (environmental)	Citations, notice of violation, violation notice, violation
		Environmental expenses and investments	Environmental expenses/investments; refer to performance data

Dimensions		Elements	Keywords/ location
		Fines (environmental)	Fines; refer to performance data
		Green technologies research & development	Green/alternative/renewable, research and development, R&D
		Protection of marine ecosystems	Marine ecosystems, marine
		Recovery of spilled fuel	Spill, spilled fuel, fuel spill, oil spill, spill to water
		Pipelines, monitoring and maintenance	Pipelines, pipelines monitoring, pipelines maintenance
		Accidental spills	Spills, oil spill, spill to water
	Materials usage	Life cycle analysis (LCA)	Life cycle analysis, eco-balance, cradle-to-grave
	Recycling	Waste recycled: solid waste	Refer to performance data
		Waste (office) recycled	
		Materials recycled: wastewater	
	Waste	Waste (solid) disposed of	Refer to performance data
		Waste (hazardous) produced	
		Waste (hazardous) released to the environment	
		Waste water released to natural water bodies	
	Water	Water used	Refer to performance data

Table Ib – Social sustainability indicators

Dimensions		Elements	Keywords/location
Social Intent	Accountability	Health & safety, or social organizational structure	Management approach, governance, committee (usually at 'How we operate' section
		Third party validation	Verification/ assurance statement; usually located towards the end of report
	Management	Workforce profile: Ethnicities/race	Workforce - ethnicity/ies, race, distribution, composition
		Workforce profile: Gender	Gender, female, male
		Workforce profile: Age	Age
		Emergency preparedness program	Emergency, emergency preparedness, emergency program, preparation for emergency, emergency training
		Employee training for career development	Education, training, workshop, course(s), employee development
	Policy	Social **policy** statement	Usually located at vision/mission statement, management approach, values statement
		Code of conduct or business ethics	Code of conduct, business ethics, ethics, ethical, responsible, responsibility, accountability
		Supplier screening based on social or environmental performance/ supplier management	Supplier(s) – screening, selection
	Social demographic	Employment for individuals with disabilities	Disability(-ies), handicapped, disabled person
	Vision	Social **visionary** statement	Usually located at vision/mission statement, management approach, values statement
		Social impediments and challenges	Social impediments/ challenges/ difficulty/ burden/ restriction
Social reporting	Human rights	Sexual harassment	Sexual harassment, harassment, assault
		Political contributions	Political contribution, political, political assistance, contribution to politics
		Bribery	Bribe, bribery
		Anti-corruption practices	Corrupt, corruption
		Degrading treatment or punishment of employees	Degrading treatment, punishment, punishment of employees, employee punished
		Elimination of discrimination in respect to employment and occupation	Discrimination, respect, employment
		Free association and collective bargaining of employees	Free association, collective bargaining, union, workers union
		Fair compensation of employees	Compensation, pays, salary
		Elimination of all forms of forced and compulsory labour	Forced labor, compulsory labor
		Reasonable working hours	Working hours/time, work shift
		Effective abolition of child labor	Child labor, underage
	Management	Women in management	Women
	Qualitative social	Community development	Community, community development
		Employee satisfaction surveys	Survey(s), questionnaire, satisfaction

Dimensions		Elements	Keywords/location
		Community education	Community education, training, workshop, course(s)
		Occupational health & safety protection	Occupational safety, health, protection, OSH, OSHA, SHE
		Employee volunteerism	Volunteer, volunteerism, charity
		Access to health care for employees	Healthcare, health care
	Quantitative social	Employee turnover rate	Employee/staff turnover,
		Recordable incident/ accident rate	Refer to performance data
		Lost workday case rate	
		Health & safety citations	Citations, notice of violation, violation notice, violation
		Health & safety fines	Fines
		Social community investment	Refer to performance data
		Fatal injuries	
		Serious injuries	

Appendix II

Questionnaire for BWM study

Main External Factors

1. *Sustainable Supply Chain Management* (SSCM) is defined as the management of material, information, capital flows, and cooperation amongst companies along the supply chain while taking goals from all three dimensions of sustainable development (economic, environmental and social) into account.

   Several "external factors" could affect supply chain sustainability as listed below. In your opinion, what is the MOST and the LEAST important factor?

Main criteria	Most important	Least important
Economic stability		
Political stability		
Competition		
Regulation		
Energy transition		
Stakeholder pressure		

2. You have selected *XX* force as the most important factor.

   Please determine your preference ratio of this factor over the other factors by using 1 to 9 measurement scale (1 shows equal importance and 9 means the economic force is extremely more important. Please check below for detailed explanation of 1 to 9 scales[6])

Criteria / Most important	Economic stability	Political stability	Competition	Regulation	Energy transition	Stakeholder pressure

3. You have selected XX force as the least important factor. Please determine your preference ratio of the other factor over the least important factor by using 1 to 9 measurement scale.

Least important / Criteria	
Economic stability	
Political stability	
Competition	
Regulation	
Energy transition	
Stakeholder pressure	

[6] Definition of 1 to 9 measurement scale:

1: Equal importance
3: Moderately more important
5: Strongly more important
7: Very strongly more important
9: Extremely more important
2,4,6,8: Intermediate values

Economic stability

4. Economic stability could affect company investment in business development and sustainability programs. In your opinion, which investment is the MOST and the LEAST important?

Criteria	MOST Important	LEAST Important
Capital investment program		
Investment in environmental protection programs		
Investment in social assistance programs		

5. You have selected *XX* as the MOST important factor. Please determine your preference ratio of this factor over other factors by using 1 to 9 measurement scale.

Criteria / Most important	Capital investment program	Investment in environmental protection program	Investment in social assistance program

6. You have selected *XX* force as the LEAST important factor. Please determine your preference ratio of the other factors over the least important factor by using 1 to 9 measurement scale.

Criteria / Most important	
Capital investment program	
Investment in environmental protection programs	
Investment in social assistance programs	

Political Stability

7. Sustainability programs of companies can be affected by different *Political* related factors. In your opinion, what are the *most* and the *least* important criteria?

Criteria	MOST Important	LEAST Important
Political unrest		
Opposition to company activities due to *environmental* issues		
Opposition to company activities due to *social* issues		
Shifting economic priorities of government*		
Uncertainty in government's energy policies		

*e.g. shift to social wellbeing over growth etc.

8. You have selected *XX* as the *most* important factor. Please determine your preference ratio of this factor over other criteria by using 1 to 9 measurement scale.

Criteria / Most Important	Political unrest	Opposition to company activities due to *environmental* issues	Opposition to company activities due to *social* issues	Shifting economic priorities of government	Uncertainty in government's energy policies

9. You have selected *XX* force as the *least* important factor. Please determine your preference ratio of other criteria over this force by using 1 to 9 measurement scale.

Least important / Criteria	
Political unrest	
Opposition to company activities due to *environmental* issues	
Opposition to company activities due to *social* issues	
Shifting economic priorities of government	
Uncertainty in government's energy policies	

Competition

10. An oil and gas company faces intense *Competition* from its industry peers and from other energy companies. The types of energy being developed also increase competition. In your opinion, which type of company/energy possesses the *most* and the *least* competition to an oil and gas company?

Criteria	MOST Important	LEAST Important
Alternative energy development (e.g. biofuel, wind)		
Development of unconventional O&G sources		
National O&G companies		
International O&G companies		
Other energy companies (i.e. biofuel, wind etc.)		

11. You have selected *XX* as the *most* important factor. Please determine your preference ratio of this factor over other criteria by using 1 to 9 measurement scale.

Criteria / Most Important	Alternative energy development	Development of unconventional O&G sources	National O&G companies	International O&G companies	Other energy companies

12. You have selected *XX* force as the *least* important factor. Please determine your preference ratio of other criteria over this force by using 1 to 9 measurement scale.

Least important / Criteria	
Alternative energy development	
Development of unconventional O&G sources	
National O&G companies	
International O&G companies	
Other energy companies	

Regulatory Related Issues

13. Here is the list of *Regulation* related factors affecting sustainability programs of companies. Please select the *most* and the *least* important criteria.

Criteria	MOST Important	LEAST Important
Uncertainty of current regulatory framework for emissions reduction		
Changes to compliance mechanism related to health, safety & environmental protection		
Cost related to compliance and remediation		
Regulations on materials use (e.g. REACH*)		

* REACH – EU Regulation on Registration, Evaluation, Authorization and Restriction of Chemicals

14. You have selected *XX* as the *most* important factor. Please determine your preference ratio of this factor over other criteria by using 1 to 9 measurement scale.

Criteria / Most Important	Uncertainty of current regulatory framework for emissions reduction	Changes to compliance mechanism related to SHE protection	Cost related to compliance and remediation	Regulations on materials use	Uncertainty of current regulatory framework for emissions reduction

15. You have selected *XX* force as the *least* important factor. Please determine your preference ratio of other criteria over this force by using 1 to 9 measurement scale.

Least important / Criteria	
Uncertainty of current regulatory framework for emissions reduction	
Changes to compliance mechanism related to health, safety & environmental protection	
Cost related to compliance and remediation	
Regulations on materials use	
Uncertainty of current regulatory framework for emissions reduction	

Energy Transition

16. Here is the list of *Energy transition* related criteria affecting sustainability programs of companies. Please select the *most* and the *least* important criteria.

Criteria	MOST Important	LEAST Important
Policies that promote a level playing field for energy players		
Imposition of fiscal, taxation or other measures to promote low-carbon/renewable energy		
Policy to encourage investment in energy efficiency to reduce O&G demand		
Transitional support to alternative energy as an ongoing subsidy to reduce carbon emissions		

17. You have selected *XX* as the *most* important factor. Please determine your preference ratio of this factor over other criteria by using 1 to 9 measurement scale.

Criteria / Most Important	Policies that promote a level playing field for energy players	Imposition of fiscal, taxation or other measures to promote low carbon/ renewable energy	Policy to encourage investment in energy efficiency to reduce O&G demand	Transitional support to alternative energy as an ongoing subsidy to reduce carbon emissions

18. You have selected *XX* force as the *least* important factor. Please determine your preference ratio of other criteria over this force by using 1 to 9 measurement scale.

Least important / Criteria	
Policies that promote a level playing field for energy players	
Imposition of fiscal, taxation or other measures to promote low-carbon/renewable energy	
Policy to encourage investment in energy efficiency to reduce O&G demand	
Transitional support to alternative energy as an ongoing subsidy to reduce carbon emissions	

Stakeholder pressure

19. To what extent involvement of different *Stakeholders* is important? Please choose the *most* and the *least* important stakeholders from the following list.

Criteria	MOST Important	LEAST Important
Suppliers		
Governments		
Shareholders		
Local Communities		
Education Institutions		
Competitors		
NGOs		

20. You have selected *XX* as the *most* important stakeholder. Please determine your preference ratio of this actor over another ones by using 1 to 9 measurement scale.

Criteria / Most Important	Suppliers	Govern-ments	Share-holders	Local Communities	Education Institutions	Com-petitors	NGOs

21. You have selected *XX* as the *least* important stakeholder. Please determine your preference ratio of this factor over the others by using 1 to 9 measurement scale.

Least important / Criteria	
Suppliers	
Governments	
Shareholders	
Local Communities	
Education Institutions	
Competitors	
NGOs	

Appendix III

Questionnaire for industry survey

TRANSPORT & LOGISTICS GROUP
FACULTY OF TECHNOLOGY, POLICY & MANAGEMENT
DELFT UNIVERSITY OF TECHNOLOGY
THE NETHERLANDS

"Contextual factors of sustainable supply chain management practices in the oil and gas industry"

Dear Sir/Madam,

Thank you very much for participating in this study. The questionnaire will require approximately **20-25 minutes** to complete. It is divided into **4 sections** which are as follows:

1. *External factors*: external business-related factors – e.g. economic, political & stakeholder pressure;
2. *Supply chain sustainability objectives*;
3. *Sustainability orientation*: internal organizational-related factors (i.e. preparedness and commitment towards sustainability) e.g. risk management & top management involvement;
4. *Sustainable supply chain management*: actual integration of sustainability into supplier management, logistics management, operations management & product stewardship practices.

Please mark the answer that best describe your company's operating environment and practices *for each of the question.* For example:

How important is the following issues to your **stakeholders**?

	Not important	Less important	Important	Very important	Extremely important
The impact of further use of O&G on the environment			/		
Safety, health & environmental impact of *operations*				/	

Thank you again for taking time to assist us. Your participation is highly valuable to this study. If you have any questions regarding the questionnaire or the project, please do not hesitate to contact us.

Thank you.

Sincerely,

Karimah Wan Ahmad (PhD researcher)*
Prof. Dr. Ir. Lorant Tavasszy (Head of research project)
Dr. Marisa de Brito
Dr. Jafar Rezaei

*Email: w.n.k.b.wanahmad@tudelft.nl

Findings of the project (statistical summaries) will be available to all respondents who request them.
Do you wish to receive the report of this project?

☐ Yes ☐ No

Part A: External forces

This section aims to assess the external business environment of your company's operations from the following aspects: *economic*, *political*, *stakeholders*, *competition*, *regulations* and *energy transition*.

A1. Considering the **economic** condition *during the last 5 years*, to what extent your company was able to implement planned:

	Not at all	Very Low	Low	Moderate	High	Very High
Capital investment program						
Investment in environmental protection programs						
Investment in social assistance programs						

A2. To what extent did your company experience the following **political-related** situations *during the last 5 years*:

	Never	Rarely	Occasionally	Often	Very Often
Political unrest					
Opposition to company activities due to *environmental* issues					
Opposition to company activities due to *social* issues					
Shifting economic priorities of government*					
Uncertainty in government's energy policies					

*e.g. shift to social wellbeing over growth etc.

A3. To what extent is your company affected by **competition** from the following *energy producers/sources of energy*?

	Not at all	Very Low	Low	Moderate	High	Very High
Alternative energy development, e.g. biofuel, wind						
Development of unconventional O&G sources						
National O&G companies						
International O&G companies						
Other energy companies, i.e. biofuel, wind etc.						
Companies other than oil & gas operators/producers						

A4. To what extent do the following **regulatory-related** factors affect your company's operations?

	Not at all	Very Low	Low	Moderate	High	Very High
Uncertainty of current regulatory framework for emissions reduction						
Changes to compliance mechanism related to health, safety & environmental protection						
Cost related to compliance and remediation						
Regulations on materials use (e.g. REACH*)						

* REACH – EU Regulation on Registration, Evaluation, Authorization and Restriction of Chemicals

A5. With regard to the **transition to low carbon energy systems**, to what extent do the following factors affect your company:

	Not at all	Very Low	Low	Moderate	High	Very High
Policies that promote a level playing field for energy players						
Imposition of fiscal, taxation or other measures to promote low-carbon/renewable energy						
Policy to encourage investment in energy efficiency to reduce O&G demand						
Transitional support to alternative energy as an ongoing subsidy to reduce carbon emissions						

A6. To what extent does your company involve the following **stakeholders**, at the *strategic level*, in addressing sustainability issues?

	Not at all	Very Low	Low	Moderate	High	Very High
Suppliers						
Governments						
Shareholders						
Local communities						
Education institutions						
Competitors (i.e. other industry players)						
Non-governmental organizations (NGOs)						

Part B: Supply chain sustainability objectives
This section aims to assess your company's sustainability goals which are related to supply chain management.

B1. Currently, to what extent is your company focusing on the following issues? (i.e. focus based on management hours spent, money spent or how much has been written on an issue in sustainability report)

	Not at all	Very Low	Low	Moderate	High	Very High
Development of unconventional O&G						
Alternative energy development (e.g. biofuel, solar etc.)						
Safety, health & environmental management						
Provide guidance on company's operations to stakeholders						
Transparency of sustainability performance reporting						
Energy security						
Resource efficiency						
Sustainability of *supply management* practices						
Sustainability of *logistical* activities						
Product responsibility						

Part C: Sustainability orientation
This section aims to assess your company's orientation towards sustainable practices through the following aspects: *commitment to sustainable practices* and *management preparedness*.

Part C1: Commitment to sustainability

C1.1. To what extent does the following **organizational culture** describe your company?

	Very Low	Low	Moderate	High	Very High
Open					
Competitive					
Team oriented					
Centralized					
Proactive					
Innovative					
Flexible					
Opportunistic					
Risk taker					
Predictable					
Sustainable					

C1.2. To what extent does the **top management** of your company demonstrate the following commitment?

	Very Low	Low	Moderate	High	Very High
Key role in creating sustainability values					
Generates consensus on future direction for sustainable development					
Encourages long-term strategic thinking in sustainable development					
Provides resources for employees to learn sustainability-related knowledge					
Ensures that sustainability performance measurement system is continually improved					

C1.3. With regard to **transparency**, to what extent do the following initiatives are being practiced in your company?

	Very Low	Low	Moderate	High	Very High
Regular updates of sustainability performance on the corporate's website					
Invites stakeholders for company visits					
Prompt response to sustainability-related inquiry/report					
Provide guidance & clarification on company's operations to stakeholders					
Performance disclosure based on sustainability guidelines (e.g. Global Reporting Initiative (GRI) or the *International Petroleum Industry Environmental Conservation Association* (*IPIECA*)					

Part C2: Management preparedness

C2.1. In **managing risk**, to what extent does your company monitor the following aspects?

	Very Low	Low	Moderate	High	Very High
Political condition					
Economic condition					
Law and regulations related to safety, health & environmental protection					
Safety, health & environmental risks of *products*					
Safety, health & environmental risks of *logistical activities*					
Preparedness for emergency situation					
Ethical business conduct of suppliers					
Relationship with stakeholders					
Progress of alternative energy development					

C2.2. To what extent does your company use **cross-functional teams** (i.e. a group of people with different functional expertise working toward a common goal) to manage:

	Very Low	Low	Moderate	High	Very High
Safety, health & environmental impact of *operations*					
Safety, health & environmental risks of *products*					
Safety, health & environmental risks of *logistical activities*					
Resource efficiency (e.g. use of energy, water etc.)					
Suppliers					
Stakeholders					

C2.3. In terms of **performance management**, to what extent does your company:

	Very Low	Low	Moderate	High	Very High
Use formal metrics to *measure* sustainability *performance*					
Use formal metrics to *quantify* sustainability *benefits*					
Link sustainability to measurement and reward systems					
Use information system to manage sustainability-related data					
Review company-wide sustainability performance management systems *regularly*					

Part D: Sustainable supply chain management

This section aims to assess supply chain management practices in your company specifically on the following aspects: *supplier management*, *operations management*, *product stewardship and logistics management*.

D1. How important are the following factors in **supplier selection** decisions of your company?

	Not important	Less important	Important	Very important	Extremely important
Supplier firm reputation					
Size of supplier firm					
Delivery performance					
Relative price/cost					
Quality of service/product					
Supplier's environmental certification					
Ability to meet company's sustainability requirements					
Code of business conduct of supplier					
Contract compliance					
Communication openness					
Supplier financial conditions (i.e. assets and liabilities)					
Likelihood of long term relationship					
Technical capability					
Innovation capability					
Supplier's cost-reduction capability					
Geographical location					

D2. To what extent the following statements reflect **supplier development** practices in your company? We:

	Very Low	Low	Moderate	High	Very High
Help suppliers to set their sustainability goals					
Guide suppliers to have their own environmental & social sustainability programs					
Go into our suppliers' organizations to help them improve sustainability performance					
Run workshops/seminar to educate suppliers					
Bring together suppliers in the same industry to share their know-how and problems					

D3. In terms of **local supplier management**, to what extent are the following being practiced?

	Very Low	Low	Moderate	High	Very High
Working group for creation of business opportunities					
Annual update of local content strategy					
Direct relationship with local suppliers					
Requires foreign suppliers to cooperate with local businesses					
Facilitate access to credit and financing assistance/options					

D4. In **operations management**, to what extent does your company:

	Very Low	Low	Moderate	High	Very High
Use electricity generated from renewable sources					
Recycle hazardous waste					
Recycle waste water					
Work with suppliers in waste minimization					
Conduct equipment test & maintenance					
Train employees on occupational health & safety protection					
Use environmental management systems (e.g. ISO 14000)					

D5. In terms of **product stewardship** (i.e. product responsibility), to what extent does your company:

	Very Low	Low	Moderate	High	Very High
Involve potential suppliers during new product development					
Undertake life cycle assessment during product design stage					
Use environment-friendly alternative components/ materials					
Tailor product safety warnings to comply with current and emerging regulations					
Assess compliance with product safety legislation both where the products are made and in their intended markets					
Design product packaging to be safe & ecologically sound					
Reclaim packaging materials					

D6. To what extent are the following options to make the supply chain more sustainable considered in your company's **logistics management** decisions?

	Very Low	Low	Moderate	High	Very High
Transport safety & health:					
Safety & health risk of transport mode					
Safety & health of drivers (e.g. driving & resting time)					
Transport safety training for drivers					
Inspection & maintenance of vehicles					
Planning & scheduling					
Accessibility of transport infrastructure					
Use of multi-modal transport to reduce environmental impact					
Optimization of vehicles utilization					
Travel distance optimization					
Environmental management					
Use of energy efficient vehicles					
Preference for environmental-friendly transport mode (e.g. pipeline is preferred more than land transport etc.)					
Invest in vehicles designed to reduce environmental impacts					
Recycle/ reuse container					
Use of recyclable packaging/pallet systems					
Require suppliers to take back their packaging/pallet systems					
Collect packaging/pallet systems from suppliers					

Part E: Company profile
Please be assured that the information you provide will be kept strictly confidential. Any identifying information will only be used to send the results of this study should you choose to receive it.

1. Which of the following type(s) of operations best describe your company? (You can choose more than one answer)

Type of operations	
Drilling & well services	☐
Equipment repair	☐
Exploration & production	☐
Refining/petrochemical	☐
Fabrication & construction	☐
Manufacturers & suppliers	☐
Transportation	☐
Others (please specify): _____	

2. Please indicate the approximate number of employees in your company.

Less than 1,000	☐
1,001 – 5,000	☐
5,001 – 10,000	☐
11,001 – 15,000	☐
15,001 – 20,000	☐
20,001 and more	☐

3. Please indicate your company's turnover (last year):

Less than $100 millions	☐
$101 - $250 millions	☐
$251 - $500 millions	☐
$501 - $750 millions	☐
$751 - $1 billion	☐
$1.1 - $5 billions	☐
More than $5	☐

4. In how many countries does your company operate in?

Less than 15	☐
16 – 30	☐
31 – 45	☐
46 – 60	☐
61 countries & above	☐

5. Please select the region(s) where your company operates in:

Asia-Pacific	☐	Eastern Europe	☐
Southeast Asia	☐	Western Europe	☐
Middle East	☐	Central Europe	☐
North America	☐	North Africa	☐
South America	☐	Sub-Saharan Africa	☐
Northern Europe	☐		
Southern Europe	☐		

6. Please indicate the region in which the ***majority*** of your company activities are conducted:

Asia-Pacific	☐	Eastern Europe	☐
Southeast Asia	☐	Western Europe	☐
Middle East	☐	Central Europe	☐
North America	☐	North Africa	☐
South America	☐	Sub-Saharan Africa	☐
Northern Europe	☐		
Southern Europe	☐		

7. Please indicate if your company is a member of the following network (you can choose more than one):

The World Petroleum Council (WPC)	☐
The World Energy Council (WEC)	☐
International Association of Oil & Gas producers (OGP)	☐
International Petroleum Industry Environmental Conservation Association (IPIECA)	☐
The oil companies' European association for environment, health and safety in refining and distribution (CONCAWE)	☐

Others, please state: _____

8. Please state your job title in the company: _____

9. How long have you been working in the company?

Less than 5 years	☐
6 – 10 years	☐
11 – 15 years	☐
16 – 20 years	☐
21 – 25 years	☐
More than 25 years	☐

10. Do you wish to receive the report of this project? If yes, please state your email address:
_____

The end
Thank you for your participation and cooperation

About the author

Wan Nurul Karimah Wan Ahmad was born on 11 July 1984 in Terengganu, Malaysia. She completed her bachelor degree in Management of Technology at Universiti Tun Hussein Onn Malaysia (UTHM) in 2006. She worked at the university as a tutor after her graduation. In 2009, she received a master degree in Engineering Management from Universiti Putra Malaysia. From 2010 to 2016, she was a PhD student at Delft University of Technology. Both of her master and doctoral education were supported by the Ministry of Higher Education Malaysia. Her current research interests include sustainable supply chain management, sustainable energy development and energy transition.

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