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Exploring supply chain sustainability practices in the Gulf Cooperation Council petrochemical sector

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ABSTRACT

Oil & gas companies in the six Gulf Cooperation Council (GCC) countries are critical to improving their sustainability through enacting regulation, developing standards and practices, and monitoring environmental performance. The study investigated how the GCC Petrochemical sector is performing across its supply chains to identify sustainable best practices, performance measurement methods, and related drivers and barriers using Institutional Theory. Primary data were collected from 32 respondent interviews from the GCC Petrochemical sector, along with a review of supporting secondary data. Four best practice pillars emerged: digitalisation, value creation, risk management, and partnerships, which are key enablers and components for sustainability. Resulting drivers, barriers and related key performance indicators will inform this sector's stakeholders. Study confirmed all three Institutional Theory elements influence and impact this sector, but predominantly normative and coercive pressures, with partnerships and self-regulation practices emerging as important. Eight policy recommendations were suggested for governments to enhance sustainability implementation.

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Sustainability; Gulf Cooperation Council; petrochemical sector; supply chain management; performance measurement; institutional theory

Introduction

The six Gulf Cooperation Council (GCC) countries of the Kingdom of Saudi Arabia (KSA), the United Arab Emirates (UAE), Bahrain, Qatar, Kuwait and Oman derive much of their gross domestic product (GDP) from the oil & gas (O&G) industry (World Bank 2022). The petrochemical sector of the O&G industry (hereinafter after referred to as 'the sector') is a downstream customer of O&G producers and is responsible for refining and processing and then selling on various product derivatives from crude oil and natural gas feedstocks, more commonly referred to as 'fossil fuels' (such as petrol, diesel, kerosene and other fuels, plastics, and fertilisers).

Notwithstanding criticisms of this industry's sustainability profile generally across the globe, i.e. with protests over 'just stopping oil' or reducing the globe's need to use fossil fuels, the use of this industry's varied product mix appears to be necessary for current production and consumption as well economic growth for the foreseeable future (DW News 2024). The GCC is committed to improving sustainability in this industry, and particularly its petrochemicals sector through enacting regulation, developing standards and practices, and monitoring environmental performance,

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and has also committed to international agreements such as the Global Methane Pledge and COP28 (Agility 2023).

However, pricing of crude oil and natural gas, and its product derivatives, is based on monopolistic market competition (MacFadyen and Watkins 2014) and fostered by large, multinational oil producers such as British Petroleum (BP), Shell Global and Exxon Mobile, and the Organization of the Petroleum Exporting Countries (OPEC), whose mission is to '*coordinate and unify the petroleum policies of its member countries … ensure stabilization of oil markets … to secure an efficient, economic and regular supply of petroleum to consumers, a steady income to producers and a fair return on capital*' for investors (OPEC 2024). KSA, UAE and Kuwait are the only GCC countries who are members of OPEC.

The O&G industry has also been subject to growing scrutiny from various stakeholders pertaining to its health, safety, and environmental standards. Previous disasters both onshore and offshore, from the Piper Alpha offshore platform accident in 1988 through to the shipwreck of Exxon Valdez in 1989 and the Deepwater Horizon offshore platform accident in 2012, the latter two events spilling huge quantities of crude oil off the Alaskan coast and into the Gulf of Mexico respectively, have reinforced this scrutiny (Silvestre, Gimenes, and Neto 2017).

Furthermore, analysis of 30 O&G company sustainability reports found inconsistency in sustainability reporting practices, which lagged behind social performance reporting (Ahmad, de Brito, and Tavasszy 2016). Finally, there has been a lack of supply chain indicators in the sustainability reporting guidelines, underlying findings from Shaw, Grant, and Mangan (2021), that sustainable supply chain performance measurement remains deficient among supply chain companies.

The sustainability of supply chains in the O&G industry is increasingly critical due to environmental concerns and the need for responsible resource management. Research indicates that while there is a growing awareness of sustainability practices, significant gaps remain in the implementation and reporting of these practices across the sector (Ahmad, de Brito, and Tavasszy 2016; Egila, Kamal, and Tjahjono 2023; Hasan, Thomas, and Tomos 2024).

The O&G industry, namely the sector, plays a vital role in the global economy as petroleum and crude oil has become the key fuel source, powering economies and society, responsible for industrial revolutions and global economic development. Yet, the sector accounts for 56% of all energy-related carbon dioxide (CO_2) emissions (which includes Scopes 1,2 & 3 carbon emissions), this represents approximately 40% of total GHG emissions (International Energy Agency 2025). Given the climate change crisis, this now poses one of the most severe risks to the sector, which is how quickly they can transition to a low carbon economy. Added to this, global energy demand will increase by one third by 2040, and demand for oil and other liquid fuels will continue to grow over the next decade, peaking around 2030 (Lu, Guo, and Zhang 2019). The challenge for the sector is how to decouple growing demand and reliance on oil and gas. A further challenge is that 75–90% of an organisation's carbon emissions originate from within the supply chain itself and the O&G industry is not on track to meet climate change targets set by the Paris Agreement (Dietz et al. 2021; Hettler and Graf-Vlachy 2024). The Gulf region holds more than 30% of the world's crude oil and 20% of its natural gas reserves (British Petroleum 2021), producing one third of the world's fossil fuels.

As a result, there appears to be a 'sustainability paradox' between balancing environmental ambition and practices, but also strategy and income for investors (i.e. oil and gas is a profitable and lucrative), (MacFadyen and Watkins 2014; Silvestre, Gimenes, and Neto 2017). This 'sustainability paradox' underpins the rationale and motivation for this study and the need to urgently understand the current state of the GCC petrochemical sector, in particular the sustainable supply chain practices and performance of these stakeholders. This is key and an enabler in addressing the sustainability challenges of one of the largest carbon emitting industrial sectors, contributing to the global climate change crisis.

While there are some studies (including literature reviews, reviews of secondary data), which address sustainability of O&G industry, globally, there is a dearth of empirical studies which specifically address the challenges of sustainable practices in the GCC petrochemical sector (Aljanadi and Alazzani 2023), from the perspective of the practitioners themselves.

The paper provides an in-depth qualitative view of how GCC petrochemical companies are implementing sustainability into their supply chains to identify sustainable best practices, performance measurement, and related drivers and barriers used within their supply chains. The study adopts an Institutional Theory (IT) perspective in an exploratory empirical study setting, providing a unique view through the eyes of the sector itself.

This paper is structured as follows, firstly, we provide a comprehensive review of the literature to date on sustainable supply chain practices within the Petrochemical sector context, identifying key gaps and theoretical underpinning leading to the development of the key research questions. Secondly, the methodological approach is presented. Finally, the key findings, discussion, conclusions and recommendations are discussed.

Literature review

The following literature review focussed on three main themes: sustainable supply chain management, supply chain risk management, and sustainability in the O&G industry in general, and in particular, within the GCC Petrochecmial sector as the context of study.

Sustainability and sustainable supply chain management

The primary definition for supply chain management (SCM) relates to a throughput process of goods and services from point or origin to point of consumption with attendant relationships among various supply chain actors, including a 'focal firm' and its suppliers, customers and other stakeholders such as government and non-government organisations (Grant 2012). The O&G industry and the Petrochemical sector are primarily throughput process industries of basic commodities – petrol or diesel fuels sold to consumers and other customers comprise the same basic source of crude oil, albeit refined slightly differently.

Stakeholders are particularly important regarding sustainability in supply chains and SCM as 'influencers' or 'rule makers' in the case of governments and relevant non-government organisations (NGOs), such as accounting standards bodies (Grant, Trautrims, and Wong 2022). Any regulations or standards likely also accrue to actors along the supply chain, upstream and downstream (Grant 2012), particularly in the O&G industry which is more heavily regulated than some other industries (Silvestre, Gimenes, and Neto 2017).

Carter and Rogers (2008) were among the first scholars to delineate sustainable supply chain management (SSCM) as the strategic, transparent integration and achievement of an organisation's social, environmental and economic goals in the systemic coordination of key interorganisational business process is for improving the long-term economic performance of the individual company and its supply chains. These goals were derived from Elkington's (1994) triple bottom line or TBL for sustainable development of economic, environmental and social elements. Much literature about SSCM has been developed since Carter & Rogers' theoretical contribution over 15 years ago (see Khan et al. 2021 for a recent and useful compendium on this topic), however much work remains on SSCM strategic elements and SSCM measurement and indicators (Gardas, Raut, and Narkhede 2019; Shaw, Grant, and Mangan 2021).

Ahmad et al. (2016) explored the relationship between external factors in the O&G industry business environment and supply chain sustainability goals to understand those factors that could drive or inhibit adoption of SSCM practices. They examined relationships between six external factors, political stability, economic stability, stakeholder pressure, competition, energy transition and regulations, and sustainability goals using survey data from O&G industry companies and analysed using multiple regression. The analysis revealed two types of sustainability goals, strategic goals conditional for long term or economic survival, and functional goals closely related to companies' operational processes. Stakeholder pressure and economic stability were found to be the most influential factors affecting these goals while O&G industry competition positively

effects functional goals. Competition from the broader energy industry, e.g. offshore wind and electricity, negatively affects strategic goals while energy transition influences a higher focus on strategic goals.

Performance measurement and performance indicators, also referred to as key performance indicators or KPIs, have been commonplace in business and companies for many decades. Traditional tools and frameworks underlying such indicators or KPIs include Benchmarking, the Balanced Scorecard (BSC), the supply chain operations reference (SCOR) model, and the performance prism (Shaw, Grant, and Mangan 2010).

Traditionally, supply chain performance measures have been orientated around cost, time, and accuracy. A key issue surrounding performance measurement is 'what' to measure and 'how' to measure it (Grant and Shaw 2019). In contrast, sustainability performance measurement is a recent development due to increasing interest over the last 20 years concerning issues of climate change, diminishing raw materials, a need for cleaner production and excess waste reduction, increased levels of pollution, globalisation, and gaining a competitive advantage from sustainability (Shaw, Grant, and Mangan 2021).

Sustainable supply chain performance measurement is a multidimensional, complex business problem. Issues such as non-standardised data, access to data, technology restrictions, stakeholders, culture, products, government regulations, organisational policy, industry, country, and company size can all negatively drive or act as a barrier to the implementation of efficient and effective sustainable supply chain performance measures and practices.

A great deal of research and practice on sustainable supply chain performance measurement has focused on reducing greenhouse gas (GHG) emissions due to their overwhelming impact on climate change. Supply chains are crucial to the low carbon transition, accounting for around 60% of total global greenhouse emissions and between 75–90% cradle-to-gate carbon emissions originating within the supply chain (Hettler and Graf-Vlachy 2024).

However, companies have recently begun seriously considering broader sustainable management issues, not only from a mitigation legislative perspective, but also from an adoption perspective. The emergence of Environmental Social Governance (ESG), originally driven by the financial sector for investors, has focused attention not only on the 'E' (environmental) in ESG, but also the 'S' (social) and the 'G' (governance) which supports, and holds organisations account for their sustainability performance. ESG policy and strategies are underpinned by the 17 x United Nations Sustainable Development Goals (United Nations SDGs 2025), and supply chains are fundamental in the delivery of sustainability, especially for decarbonisation initiatives and carbon emissions. Integrating Environmental, Social, and Governance (ESG) principles into the sector is increasingly recognised as essential for enhancing operational efficiency, corporate valuation, and sustainability. Research indicates that ESG adoption can significantly improve managerial performance and key financial metrics, such as Return on Assets and Market Capitalisation, as evidenced by studies on major companies like ONGC and IOCL (Bharti and Kumar 2024); also enabling sustainable transformation (Agbaji, Morrison, and Lakshmanan 2023).

The adoption of additional sustainable measures, whether accredited, audited or not, will provide a company with an environmental management system (EMS) to manage and report on its environmental or ESG performance (Grant and Shaw 2019). The problems caused by materials (e.g. pollution) or infrastructure added to the system or removed from the system (e.g. aggregates,) requires a risk assessment framework. This is then managed using the actions through vertical integration of governance and the horizontal integration of stakeholder action.

Sustainability and risk management in supply chains

Risk management is an important part of any company's ESG strategy and policies, and has always been important for companies and supply chains in many industries (Rafi-Ul-Shan et al. 2018). This situation has been amplified since the COVID-19 pandemic disrupted world economies and global

supply chains, regardless of country size or national economy development. Such disruptions have forced all companies to investigate and evaluate risks and vulnerabilities within their supply chains (Gurtu and Johny 2021).

There is some disagreement among academics regarding a definition of supply chain risk management (SCRM), however there is concurrence that SCRM practices seek to reduce supply chain vulnerability and mitigate the impact of disruptions (Rafi-Ul-Shan et al. 2018). A desire for better SCRM practices leads to action sets for an intended result, requiring a prerequisite for coordination and collaboration among supply chain actors to identify, assess, mitigate and monitor risks to reduce vulnerability and increase robustness and resilience of the supply chain, ensuring profitability and continuity (Baryannis et al. 2019).

The O&G industry, including the sector, deals with dangerous materials at different stages in its supply chain. If these materials are treated in unsustainable ways, they may negatively impact a company's operations and its workforce, as well as society or the environment. Further, the global reach of the GCC's petrochemical sector leads to one of the most extended supply chains worldwide. Such a long supply chain has a greater risk of disruption or failure (Okeke 2021). As a result, this is heavily regulated as regards quality, pollution and health & safety (Schneider et al. 2013) beyond sustainability in operations, and has been since its inception last century.

For example, one of the most important risks to humans from the natural gas extraction and refining process is the release of hydrogen sulphide (H_2S), which has a 'rotten egg gas' smell at low concentrations so humans are aware of its existence in the immediate environment. However, if that smell disappears the concentration is increasing such that it could poison humans by not allowing them to receive sufficient oxygen to breathe properly. Popular techniques that have been developed over the decades include separation of H_2S through membranes or the use of 'scrubbers' in the exhaust stacks at refineries (Alexander and Winnick 1994).

One example of a sustainability risk management tool was provided by Giannakis and Papadopoulos (2016), who argued that supply chain sustainability from an operational perspective should be considered as a risk management process. Their framework, shown in Figure 1, is driven by TBL considerations driving possible cause where the possible impacts are also TBL and operational elements. Their approach is similar to Grant and Elliott's (2018) interdisciplinary framework where the Drivers-Activities-Pressures-State Changes-Impacts (on human Welfare)-Responses

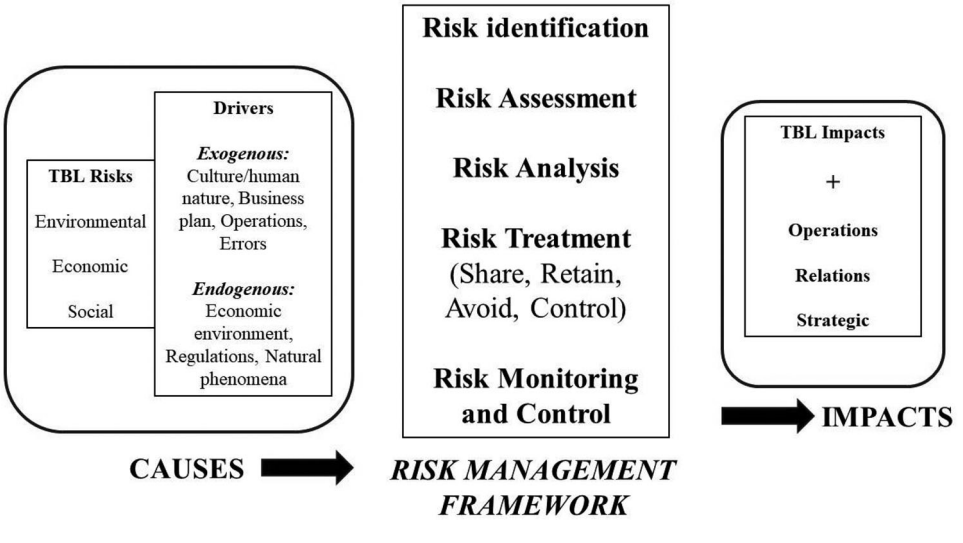

Figure 1. Example of sustainability risk management framework. Source: Adapted from Giannakis and Papadopoulos (2016) by authors.

(as Measures), or DAPSI(W)R(M), problem structuring method integrating the 10-tenets of sustainable management and stakeholder consultation criteria with a Bow-Tie risk assessment and management analysis approach.

The 10-tenets criteria provide a way to evaluate whether a proposed environmental management solution is socially desirable/tolerable, ecologically sustainable, economically viable, technologically feasible, legally permissible, administratively achievable, politically expedient, ethically defensible, culturally inclusive, and effectively communicable. These frameworks both point to a need for integrated sustainability risk management approaches to facilitate the development of effective sustainability strategies.

Risk can thus be a primary source of disruption, which may ripple through the supply chain, and the role of an SCRM system is to ensure smooth functioning and risk-free supply chains functions. Hence, consideration of SCRM is vital as it deals with unexpected challenges facing companies related to the economy and globalisation, which increases uncertainty within the supply chain (Gurtu and Johny 2021). Thus, exploration of supply chain sustainability in the GCC Petrochemical sector, or indeed anywhere in the world, must consider issues of SCRM.

The Safety & Quality Assessment for Sustainability (SQAS) system aims to measure and mitigate risks for the sector, monitoring sustainability levels, such as quality, safety, security and environmental requirements of logistics providers in the distribution of European and GCC region chemicals, therefore the O&G must comply with the standards that are set for global distribution of their products from the GCC region (Torres-Rubira, Escrig-Tena, and López-Navarro 2023).

Geopolitical risks are also prevalent in the O&G industry and Petrochemical sector. Political instability and conflicts, such as the Qatar-Gulf crisis, significantly affected the oil and gas markets by introducing uncertainty and volatility in oil prices (Bouoiyour and Selmi 2019). Key logistics shipping corridors, such as the Suez Canal and the Gulf of Eden, have been targeted over recent years by political and terrorist groups, to disrupt these main trade routes for O&G.

Sustainability in the oil & gas industry and the petrochemical

Schneider et al.'s (2013) study of annual reports and sustainability reports for ten major public oil and gas companies (British Petroleum or BP, Chevron, Conoco Philips, ENI, Exxon Mobile, Marathon Oil, Shell Global, Sonatrach, Total Oil and Weatherford International) focused on their upstream operations, that is extraction, but excluded production, transportation, refining and marketing. The commonly reported metrics where product throughput, oil spill volumes and various GHG emissions such as Carbon Dioxide (CO_2), Nitrous Oxide (NO_x) and H_2S.

Schneider et al. (2013) concluded that the industry represents a significant portion of wealth and GDP for many countries, but their analysis showed evidence that differences still exist within the industry relating to environment, health & safety and sustainability, and issues such as significant non-compliance with laws and regulations is common, particularly in the U.S. In summary, these metrics have limited applicability and are over a decade old, they do provide a direction of travel.

Almost a decade later, Okeke (2021, 1001) analysed 150 annual reports over ten years of 15 O&G companies in Europe, Asia and the U.S. listed on the London Stock Exchange in the U.K., i.e. major O&G producers, to determine whether they 'report their green rhetoric by pushing their supply chain in the direction of sustainability'. He concluded there is a disparity in emphasis for supply chain sustainability and that companies in Asia and the U.S. were lagging behind Europe. This was further reinforced by Dietz et al. (2021), noting that the world's largest public O&G producers are far from being aligned with limiting global warming to 2°C or to 1.5°C set in 2015 at the Paris Agreement. Some companies have yet to set emissions targets, and some others provide limited clarity on what they cover and how they will reduce company-wide emissions.

Bathrinath et al. (2021) overviewed the O&G industry's sustainability challenges in India, examining all TBL three elements. They concluded that minimal attention has been paid by the industry in moving towards sustainability, particularly social sustainability. Regarding economic

sustainability, they recommended the O&G industry adopt Lean Six Sigma Strategies and suggested it considers adverse environmental impacts during processing stages, recommending green and sustainable manufacturing to lower consumption of non-renewable resources.

Cui et al. (2022) examined cleaner production indicator systems in China's petroleum refining, analysing them relative to existing international pollutant emission standards from a micro life cycle perspective. They found existing indicator systems cover only partial life cycle phases and ignore verification of carbon emissions, and also found high ambiguity and complexity of existing indicators as there are no widely accepted indicator systems nor a single set of scientific selection criteria and standards. They proposed new indicators placing more emphasis on carbon emissions which are ignored in traditional systems.

The GCC provides an excellent context of study as a geographical region which is essentially a commodity market. A large percentage of GCC GDP is derived from the O&G industry and the Petrochemical sector, and it significantly outweighs other O&G producing regions around the globe. In 2020, around one-third of global O&G production was produced in the Middle East region. By comparison, North America only produced 23.8% of total global volumes. The leading oil producers in the Middle East region are the GCC members. The core GCC states of KSA, UAE, Kuwait and Qatar are referred to as 'rentier states', which means most of their revenue comes from fossil fuels instead of taxation. This has led to distortion of those countries' labour markets as the workforce participation rate of their native populations is very low, and the majority of their workforces consist of expatriates (Statista 2024).

KSA leads the GCC oil production and is considered a 'swing producer' as it can increase or decrease its oil production output without significantly increasing production cost. In 2018, KSA was the leading crude oil supplier worldwide, with an export value of over USD 183 billion. Its breakeven oil price per barrel was less than half of its main global competitors, Russia and Venezuela. However, O&G GDP growth is slowing after three rounds of OPEC + O&G production cuts in 2022 and 2023. Crude oil production was cut considerably in the GCC which decelerated O&G GDP growth. However, the slowdown of O&G GDP has been partially offset by continued strong non-oil GDP growth, driven by robust manufacturing activity and surging services. Nevertheless, despite ongoing efforts to diversify GCC economies away from oil, non-oil growth is projected to be insufficient to offset the decline in oil growth over the medium term, as productivity gaps in the non-oil persist, posing challenges for job creation and inclusion (Stratulativ 2023).

External guidance for the O&G industry comes from the Global Reporting Initiative's (GRI 2023) *GRI 11: Oil and Gas 2021* report, which provides information about material topics for companies in the industry to report as part of their sustainability strategy. These topics are considered material on the basis of the industry's most significant impacts on the economy, environment, and people/social, including on their human rights. GRI 11 also contains a list of disclosures for organisations in the oil and gas to report in relation to each likely material topic and includes disclosures from the GRI Topic Standards and other sources. Table 2 lists the 22 topic areas as well as the authors allocation of each topic to either environmental, economic, or social elements of sustainability aligned with Elkington's (1994) TBL. These topic areas and specific GRI guidelines are useful in helping to develop and create robust ESG strategies for implementation.

Agility (2023) developed a Middle East and Africa Environmental Sustainability Scorecard to evaluate the environmental sustainability performance of 17 individual countries using 48 indicators derived from quantitative data, a dedicated survey of executives, and policy assessment capturing environmental sustainability related outcomes, government policies and corporate practices. The six Middle East countries evaluated were the six GCC members. Scorecard values ranged from 0–100, and the GCC countries scored as follows: UAE 57.58, KSA 51.90, Qatar 47.64, Oman 41.37, Kuwait 45.15 and Bahrain 45.88. The assessment framework used to develop the scorecard reflects key dimensions of environmental sustainability grouped into six pillars. These six pillars are compiled in Table 1.

Table 1. Six pillars of key dimension for environmental sustainability.

Pillar	Name and brief description
1	Green investment, innovation, and technology including investment flows, barriers, incentives, collaborations, and patents.
2	Sustainable infrastructure and transport capturing green certified, sustainable buildings and availability of green infrastructure roads, railways, ports and airports, including electric fleets and public transport.
3	Governance and reporting capturing the national regulatory environment, environmental sustainability commitments, and corporate reporting practises.
4	Energy transition focuses on energy supply and renewable energy use, subsidies and taxes, and energy transition agendas at national and corporate levels, including net zero and energy efficient targets.
5	Environmental ecosystems measures air, soil, and water pollution, as well as conservation efforts for biodiversity and protected areas.
6	Circularity capturing resource use efficiency and waste management

Source: Compiled by authors from Agility (2023).

Agility (2023) concluded there are six action points for business: developing better corporate vision and strategy, developing international targets and reporting, analysing materiality of impact and priority areas, developing new business opportunities, facilitating business-to-business knowledge exchange, and engaging with government. At a higher level, they concluded there are five action points for all stakeholders: leadership across the board, clarifying the national vision on sustainability, using global knowledge to identify solutions, facilitating investment, and creating positive incentives.

While the integration of ESG principles in sustainability measurement & reporting presents numerous advantages, they also pose significant challenges that require strategic innovation and collaboration to overcome. These challenges include: technological and financial constraints and the complexity of the supply chain itself (Bandeira et al. 2024; Emeka-Okoli et al. 2024). Aljanadi and Alazzani (2023) found in their assessment of the quality of sustainability reporting that the indicators used by O&G companies in the GCC countries to be lacking in detail and of insufficient quality for reporting. The O&G sector must navigate these complexities to align with global goals effectively. Key benefits include: enhanced managerial performance, corporate valuation to

Table 2. Global Reporting Initiative (GRI) topics for oil and gas.

Topic	Name	Environment (Env), Social (Soc) or Economic (Eco) Sustainability*
11.1	GHG emissions.	Environmental
11.2	Climate adaptation, resilience, and transition.	Environmental
11.3	Air emissions.	Environmental
11.4	Biodiversity.	Environmental
11.5	Waste.	Environmental
11.6	Water and effluents.	Environmental
11.7	Closure and rehabilitation.	Environmental
11.8	Asset integrity and critical incident management.	Economic
11.9	Occupational health and safety.	Social
11.10	Employment practices.	Social
11.11	Non-discrimination and equal opportunity.	Social
11.12	Forced labour and modern slavery.	Social
11.13	Freedom of association and collective bargaining.	Social
11.14	Economic impacts.	Economic
11.15	Local communities.	Social
11.16	Land and resource rights.	Social
11.17	Rights of indigenous peoples.	Social
11.18	Conflict and security.	Social
11.19	Anti-competitive behaviour.	Economic
11.20	Anti-corruption.	Economic
11.21	Payments to government.	Economic
11.22	Public policy.	Social

Source: Compiled by authors from GRI (2023).
*Authors allocation.

investors and alignment with the SDGs (Dsouza and Krishnamoorthy 2024). A great example of the value of adopting sustainability practices is DONG Energy, the Danish oil and natural gas company. They rapidly transformed into Ørsted, through a strategic shift towards renewable energy, divesting its fossil fuel businesses, and rebranding to reflect its new focus on green energy, particularly offshore wind (Rendtorff 2023), demonstrating how a low carbon business model shift can be rapidly achieved.

Literature summary and resultant research questions

In summary, sustainability in supply chains still appears to be nascent, notwithstanding academic discussions that have taken place for almost two decades. Various ESG and sustainability frameworks, concepts around the TBL, and discussions of various stakeholders such as governments, NGOs and the wider community have all added to the confusion. Furthermore, understanding within practice about making their supply chains more sustainable is even less developed with limited understanding by companies about what they should be measuring and why. Their trepidation here may be driven by different regulatory regimes and requirements as well as limited scope for supply chain sustainability performance indicators. Underlying all of this is the issue of risk and risk management which is important for sustainable supply chain management.

All these issues are exacerbated within the O&G industry and its Petrochemical sector which has been often pilloried for being on the wrong side of the environmental debate and can be even more problematic for countries such as the six members of the GCC who derive much of their economic activity and GDP through the O&G industry and petrochemical sector. Notwithstanding, there is good guidance from some sources such as the Global Reporting Initiative (GRI 2023) and Agility's (2023) environmental sustainability scorecard which is directly applicable to the GCC. Furthermore, on 14th November 2024, at COP 29 UN Climate Change Conference, the International Organisation for Standardization (ISO) introduced ISO's ESG Implementation Principles (ISO 2024: IWA 48:2024), a high-level structure and set of principles designed to guide organisations in implementing and embedding ESG and Sustainability. Consequently, the landscape of ESG, sustainability measurement and reporting is evolving rapidly, globally.

The introduction of new legislation and directives in the EU such as the Corporate Social Responsibility Directive (CSRD) and the International Sustainability Standards Board (ISSB), which will provide global standards for ESG reporting, now demand that large and listed organisations must publish and report on their social and environmental risks they face, and how their activities impact people and planet – known as 'double materiality' impact (European Commission 2025). This will consequently impact the sector.

From a theoretical perspective, institutional theory provides a powerful lens in which to understand and contextualise the pressures, drivers and barriers in implementing sustainable practices and performance in the sector. DiMaggio and Powell (1983) describe these as mimetic, normative, and coercive pressures (or forces), that drive organisations towards conforming or behaving in a particular way.

Okeke (2025) noted that O&G organisations face substantial pressures to adhere to elevated standards of environmental stewardship, mitigate land degradation, eliminate exploitative labour practices, and uphold human rights, from these institutional pressures. Yet, there is limited use of the institutional theory in the context of this problem, with historic studies focusing on singular aspects or dimensions of sustainability or specific institutional pressures, often neglecting a comprehensive ESG or institutional theory approach.

Given the considerable significance of this O&G industry and this sector in helping to reverse and mitigate the climate crisis, and to improve global sustainability, there is a need to understand these institutional pressures in-depth and more comprehensively. There has been very limited research on these issues in the O&G industry and Petrochemical sector (Okeke 2025). This paper represents one of the first empirical studies to apply IT to understand sustainability practices

within the GCC Petrochemical, through the perspectives of the key actors that work in this supply chain. This is important as external pressures impact and can explain why organisations, their stakeholders, respond in specific ways, for instance their resultant sustainability practices (or what they perceive as best practice), and also what drives or inhibits them. Accordingly, an inductive, qualitative study using semi structured interviews was determined to be the best empirical approach (as discussed in the following section) and stimulated derivation of the following three research questions to explore this phenomenon in the GCC's petrochemical and its supply chains:

- RQ1: *What are the best sustainable supply chain practices to implement among petrochemical companies in GCC countries?* Given disparities about best practices among health & safety and other forms of sustainability in the Petrochemical sector (Okeke 2021, 2025; Schneider et al. 2013), this question provides a baseline from the perspective of respondents.
- RQ2: *What is the best performance measurement system to be used for measuring the impact of sustainable supply chain management practices, and what should be measured by GCC Petrochemical companies?* Given the paucity of appropriate sustainable supply chain performance measures and measurement systems in general (Gardas, Raut, and Narkhede 2019; Shaw, Grant, and Mangan 2021), and in the O&G industry in particular (Bathrinath et al. 2021; Cui et al. 2022), this question provides understanding of what is currently in use and of importance to respondents.
- RQ3: *What are the drivers and barriers to implementing sustainable supply chain management practices in GCC Petrochemical companies?* As a follow-on from RQ2, this question provides an understanding of what respondents consider might enable or inhibit sustainable supply chain practises in the GCC.

Methodology and methods

Methodology

Based on this study's objectives, this study used a qualitative research methodology to gather in-depth and rich data to help the researcher understand a research context that has a relatively limited number of previous empirical studies (Denzin and Lincoln 2011). Given this unique and largely under-researched research context pertaining to sustainable supply chain practices in relation to the performance of the organisational performance of the Petrochemical sector in the GCC, this study's methodology followed an interpretivist and inductive approach to provide better understanding, reduce the level of complexity and develop new knowledge to guide academia and practice (Darby, Fugate, and Murray 2019). This approach was considered the most appropriate to explore this context, reflected in the three inductive research questions discussed in the preceding section, as it enabled the interpretation of the meaning for this phenomena, as opposed testing or measuring variables or hypotheses in a quantitative approach.

Theoretical framework

As discussed in the literature review, Institutional Theory (IT) is the framework applied in this context given the variety of important stakeholders and institutions within and outwith the GCC Petrochemical sector, particularly governments regarding promulgation of legislation and regulations for health, safety, and the environment (Ahmad et al. 2016; Silvestre, Gimenes, and Neto 2017).

IT is a well-developed theory (DiMaggio and Powell 1983) and contains three aspects of isomorphism, which is a constraining process that forces one unit in a population to resemble other units that face the same set of environmental conditions. The three aspects of institutional isomorphism are coercive, mimetic and normative. Coercive isomorphism comes from political influence and deals with legitimacy problems. Mimetic isomorphism is associated with standard

responses to uncertainty. Normative isomorphism is linked with professionalisation. All three mechanisms of isomorphism should be present in the GCC region; however, it may be that coercive isomorphism may be the most prevalent.

There are four potential sources of coercive isomorphism in the GCC and sector: the six GCC governments, the overall GCC council, the NGO Gulf Petrochemicals Chemicals Association (GPCA) and SQAS. The GCC governments represent elevated pressures while the GCC council and GPCA represent informal pressures alongside international environmental standards. Finally, customers and competitors in international markets can critically influence sustainability implementation.

As an additional consideration, Busse, Kack, and Bode (2016) noted that supply chain research is recognising institutional influences on supply chains but that there is little recognition that global supply chains, including the GCC, comprise different institutions. They employed an institutional distance concept to study supply chain sustainability risk, drawing on stakeholder theory and IT, which focussed on situations where a buyer and a supplier fully comply with stakeholder expectations within their own legitimacy contexts, but where a buyer's stakeholders withdrew legitimacy that subsequently harmed the buyer.

Busse, Kack, and Bode (2016) found that accounting for differing legitimacy contexts is necessary for explaining various risks, thereby substantiating that institutional distance is important for global supply chains with implications for corporate practice through highlighting inherent trade-off in global supply chains. This aspect will also need to be investigated in the GCC region.

Methods

A case study approach was used for primary research with companies in the GCC Petrochemical sector, as well as governments and NGOs (Yin 2013). A purposive sampling technique was used to select participants able to participate in the study and conveniently accessible. Selection was based on several factors such as position within their organisation, and relationships and knowledge about sustainability and supply chain management. Due to ongoing political conflict between Qatar and the KSA, gaining access to all GCC countries was not possible at the time of the study, therefore the research focused on predominantly KSA, UAE and Kuwait only (the three GCC members of OPEC).

The interview questions were developed from the literature review process. A pilot study was conducted initially to test the interview questions and refine the protocol with four respondents in KSA within Al Jubail and Riyadh. The four respondents included a logistics manager from a small organisation, a supply chain manager from a medium-large organisation, a global supply chain departmental lead from a medium-large organisation and supply chain expert from one of the largest primary companies in the Middle East. All respondents were from Petrochemical sector organisations.

For the main empirical study, thirty-two, semi-structured interviews, comprising 17 primary questions with probing sub-questions, were conducted with respondents from petrochemical companies, government and NGOs. Please see the interview protocol in Appendices 1 and 2. The interviews were conducted in Saudi Arabia (28 interviews), two from Kuwait and two from UAE. Respondent profiles comprised CEOs, VPs, General Managers, Logistics and Supply Chain Managers from the sector (Appendix 3). The interviews took approxinately 60 min to execute, face to face. The respondents had extensive experience (average 20 years) in the Petrochemical sector from a variety of roles along the Petrochemical supply chain. All participants worked directly in supply chain, logistics, performance measurement, or sustainability roles within their organisation. Participants from government and NGOs are related to environmental practices or supply chains like local content programmes in Saudi Arabia, which affects the sourcing practices of different companies. Logistics Service Providers (LSPs) are also vital to the supply chain and enhance the

supply chain's efficiency, and most companies outsource some of their SCM practices. Thus, these types of businesses were included as company respondents in the interviews to get a complete image of the Petrochemical sector.

Secondary data published by the companies, governments and NGOs was examined to provide supplemental or additional information and insights.

NVivo12 was used to code interview transcripts to find themes and interrelations in subsequent analysis. Each interview was read individually, and important parts were labelled related to one of the research questions to create codes. The interviews were conducted in Arabic, fully transcribed and translated in Arabic by the researchers, then carefully back translated to English for final validation, translation and interpretation (Maneesriwongul and Dixon 2004; Marshall and Rossman 2014).

The first step involved identifying inter-relations and interpreting the meaning of the themes from the interview transcription to reduce redundancy of the data and also patterns in the data that had similar meanings into one theme. After identifying all themes, step 2, required clustering into groups with a specific sub-theme to address the research questions from the viewpoint of the collected data. For example, for each research question major themes and sub-themes were developed. For RQ1, the research team collectively identified a variety of sub-themes emerging from the qualitative interview data translation and interpretation process, under the categories of 'why' 'what' and 'how' are best supply chain practices achieved? These themes were ratified and cross checked by the research team. These themes informed the coding and clustering process within Nvivo12 to organise and categorise the interview data for RQ1 (Figures 2 and 3). Figure 2 shows Step 1 and provides an example of the main themes and sub-themes for RQ1. Figure 3 shows Step 2 an example of the interview data clustering process for RQ1 under the 'Why' category.

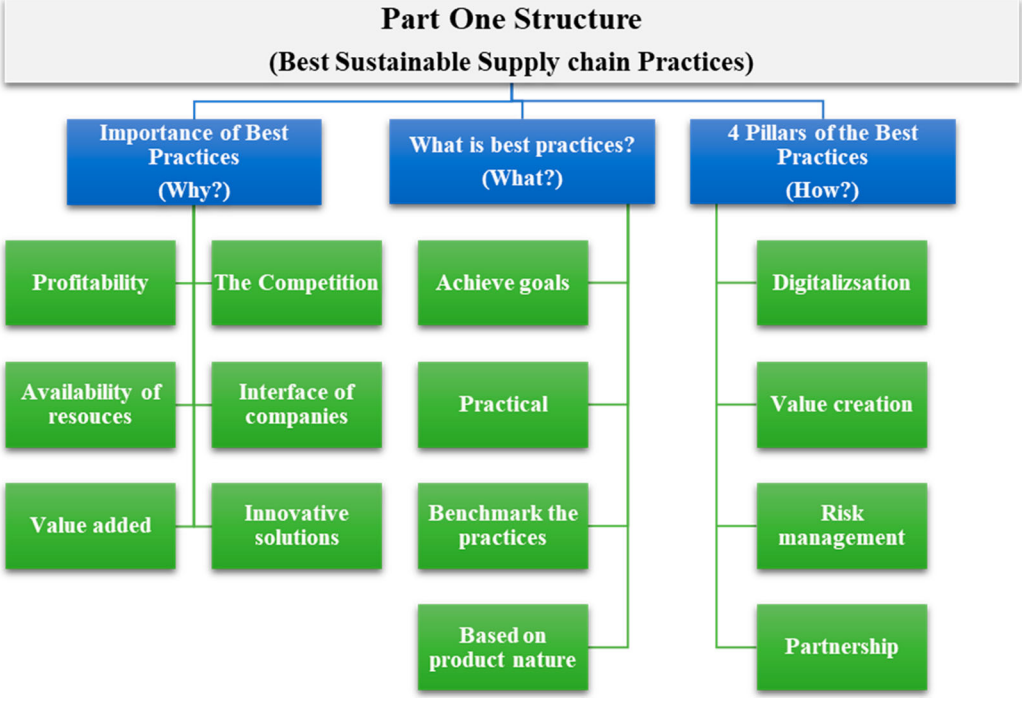

Figure 2. Step 1 – provides an example of the main themes and sub-themes for RQ1. Source: Authors.

Theme	Sub-theme	Number of Quotes	Quotes
The importance of best practices	1. The impact on profitability	1	**P(N.S.):** "All the decision-makers, […], today they understand that the profitability and losses of the company could come from the supply chain".
		2	**P(A.D.2):** "We may have a nice project and its cost acceptable, but when it comes to the supply chain, it can break the whole project, so it's vital to control your supply chain and the costs of the supply chain".
		3	**P(M.H.):** "Optimizing the cost in the supply chain makes a huge difference in the organization. Sometimes you can build your margin out of how you do it".
	2. The increase in the competition	4	**P(S.S.2):** "There is no competition between one company to another. The competition is now between one supply chain and another supply chain. Whoever has a strong supply chain will succeed in whatever industry".
		5	**P(A.M.):** "The competition in the petrochemical industry, […] they all are producing Polyethylene. The differences between them, especially when we are talking about commodity products (which represent 80% of the products), there are no major differences between them; the differences are in the services provided to the customers by the supply chain […] So, I think supply chain is the backbone for petrochemical companies".
	3. The availability of natural resources	6	**P(I.H.):** "Now the competition has increased, also the feedstock, […], now it is also available for our competitors, and it is cheaper and closer to them. […], it is less available for us. Therefore, now you need the supply chain more than before".
	4. The interface of the company	7	**P(K.D.):** "It's the face of the company with the outside world. Any defect in the performance of the supply chain will upset whether, the product receiver or the supplier who wants to sell the material".
	5. The value added to the supply chain	8	**P(M.H.):** "Each company has a nerve system; this nerve system always is the sensor and sometimes is the backbone; this is the supply chain. It's a backbone, and at the same time, it is a sensor, a nerve system. The intelligence from the supply chain is sometimes more valuable than just delivering the data, so the information going back and forth is critical. From my experience, we found out there are a lot of alerts with the customers from the supply chain".
		9	**P(S.N.):** "The supply chain is an essential component in the business, […], and its major components, it's improving your efficiency and your cost positions".
		10	**P(H.S.):** "Having a strong supply chain can sell your product. […]. So good supply chain can serve your product, create demand, and make you very competitive".
	6. Source of innovative solution	11	**P(M.H.):** "They are a source of innovation. If you build the right environment for them, they can be innovative in making things because they observe many things. We had a case in a region, […]. The supply chain came up with a massive solution; they reduced delivery time and cost and improved customer satisfaction […]. So, it's a source of innovation".

Figure 3. Example of data analysis clustering process for RQ1 (Why Theme). Source: Authors.

Findings for the research questions

Below are the emergent, factual findings for the three research questions derived from data analysis methods deployed using NVivo12 and the coding processes as discussed above. Representative quotes from respondents are provided to substantiate some of the points and a discussion and synthesis of how these findings relate to the literature and theory are presented in the following section.

Findings for RQ1

Six key findings emerged to address RQ1 regarding the best sustainable supply chain practices for the GCC's Petrochemical sector:

1. Despite probing, not many respondents discussed sustainability or the possible negative environmental impacts of this sector that deals with many high-hazard and high-risk materials, for example a teaspoon of some petrochemical liquid waste is enough to pollute 25,000 cubic metres of seawater. This might be due to a lack of respondent awareness about sustainability outside other practices.

   Most respondents believed that petrochemical companies in the GCC should implement best sustainable supply chain practices. However, a critical finding in the study is that most respondents did not mention or understand sustainability clearly or the direct environmental impacts of the Petrochemical sector. This was due to the lack of awareness of sustainability and knowledge gap.
2. Benchmarking by itself is considered a crucial practice for the supply chain, including sustainability. Without a benchmark, companies will not know if they have best practices or not, and it is also considered crucial to have a database for the benchmark. It was not evident that benchmarking was taking place across the respondent organisations, thus mimetic institutional pressure was not as prevalent. One respondent noted that '*When you say best practice, you should benchmark. Today in KSA unfortunately we don't have benchmarking in the supply chain; the benchmarking honestly is zero. You're trying to measure yourself, we*

don't have a database to tell you this is your benchmark. So, for best practice today we only have international best practice. The consulting firms come in and say this is the best practice, but we don't know whether it really is.'

3. Four main themes were derived from respondents regarding the best supply chain practices and are considered 'pillars' of supply chain best practices for GCC petrochemical companies. The four pillars are digitalisation, value creation, risk management, and partnership and further detail on them are provided below in the Discussion section. These are viewed as key enablers and components of sustainability through the eyes of the respondents.
4. Respondents believed the supply chain's primary role is to create value for the business, not cost reduction. Value creation aims to make the supply chain a strategic department and share in the company's decisions. However, they note that creating value requires creativity. For example, one responded that '*The aim of value creation is I don't want people to see the supply chain as a processing or transition or support service. I want to be neck to neck; if we are not part of the strategy and the leader of our project does not not have good experience, we will lose our project. The uniqueness in the supply chain is that you see all the variables in front of you including suppliers in the market. Also, you see yourself from inside and you see it every day. This is the uniqueness of the supply chain; The feasibility is important in it.*'
5. In the GCC there is a focus on sustainability inside 'factories' or 'operational units' in the sector, which includes health and safety, but the situation is different outside them and requires improvement. Risks surround this so sustainability must be considered both internally and externally. In addition, companies will not have a sustainable supply chain without risk management as uncertainty is the most significant risk facing them. Yet another respondent noted that '*If your products are specialty products, the supply chain for them is risky and this will increase challenges in the logistics department. The department had a committee that categorised all our products and based on that we made a matrix for each product, what is the risk and shelf life, and developed a material safety data sheet. Based on that we know the nature of our product and how it should be stored and transported. We educated our customers and thus built a strategy to mitigate risk and control our materials and contacts. For example, we could ask what is the expected risk if we don't receive product X on time.*'
6. Partnerships can be with competitors through a buying consortium, which is one of the sourcing practices. They enhance a company negotiating position, promote shared costs between companies, and enhance sustainability for all.
7. Key current sustainability practices emerged, for instance where possible modes of transport for transporting liquid or solids are pipeline and train, which are low carbon modes of transport. The use of ERP systems and digital is an important practice as it helps the supply chain departments to link different stages in the supply chain network together, which enables the flow of information and materials. An example of planning practices under digitalisation is the use of a tool under the ERP system called Advance Planning Optimiser (APO).

   Digitalisation is the trend among petrochemical companies in the GCC region, especially when dealing with low value and big quantity commodities, to improve efficiency, optimise cost, and improve sustainability and overall performance.

Findings for RQ2

Six key findings emerged to address RQ2 regarding the best sustainable supply chain measurement system and measures:

1. Unexpectedly, performance measurement systems such as the BSC and the SCOR model are not used in GCC petrochemical companies; the prime source of performance measurement are KPIs. This is contrary to findings from Shaw, Grant, and Mangan (2010; 2021). One

respondent noted that '*You must ensure that you have checked, balanced and validated KPI's. You don't take them as they were given. You must dig deep and understand how they come, the bases, and the calculation. Missing the KPIs will reduce their value. Like a car, it's a useful transportation method but if you misuse it by not respecting traffic regulations it will be dangerous*.'

2. GCC petrochemical companies give more weight to customer satisfaction than any other element related to cost. Therefore, normative institution pressure is a dominant pressure or driving force in this sector. Further they also give more weight to customer satisfaction than their sustainability or environmental impact. This again may be due to a lack of sustainability awareness and the focus on traditional performance measurement dimensions, such as cost, time and accuracy. Another respondent noted that '*My primary evaluation is what I hear from our customers. This is the measurement of success. It's important to be very responsive to the customer's needs when he is a problem so our KPIs have become customer satisfaction*.'
3. When it comes to sustainability KPIs, GCC petrochemical companies give much more weight to health & safety metrics such as accident rates than environmental metrics, like CO_2 emissions. This perhaps is linked to coercive and normative forces from regulations such as SQAS, customers, also company reputation. This demonstrates why petrochemical companies in the GCC have excellent records when it comes to accidents and health & safety, but not other environmental issues. This supports the work of Aljanadi and Alazzani (2023) who found sustainability reporting indicators used by O&G companies in the GCC countries to be lacking in detail and of insufficient quality for reporting.
4. In KSA, the Royal Commission of Jubail and Yanbu are playing crucial roles in monitoring the environmental performance of the Petrochemicals sector, especially pollution, and the implementation of international environmental agreements, such as SQAS. Therefore, coercive institutional pressure is also a dominant force in influencing what is measured and reported. Okeke (2025) noted that O&G organisations face substantial pressures to adhere to elevated standards of environmental stewardship, mitigate land degradation, eliminate exploitative labour practices, and uphold human rights, from key institutional pressures. They also found normative and coercive forces dominant in this sector, less so mimetic.
5. This research determined the most important sustainability KPIs for this sector, as identified by respondents, and they are presented in Table 3. But there is a significant gap between what the GRI set out as best practice measurements for the sector (Table 2) and where the GCC Petrochemical sector is currently at (Table 3), with regards to the current state of sustainable performance measurement and reporting. Key measurement areas lacking for instance are biodiversity, EDI and modern day slavery policies. Key measurement areas covered are predominantly environmental, economic and some social, but predominantly the KPIs are driven by operational/cost efficiency. Okeke (2021) also found European O&G companies measured across the three dimensions of sustainability, but Asian and U.S. companies were lacking and underdeveloped.

Table 3. Sustainability KPIs noted by respondents.

Sustainability KPIs	Number of respondents	ESG/GRI Theme
Accident rates	22	Social
Percentage waste	17	Environmental
Energy consumption	17	Environmental
Percentage related to corporate social responsibility (CSR)	17	Social
CO_2 emissions	15	Environmental
Usage of recycled materials in operations	11	Environmental
Product loss / leakage	1	Economic

Source: Authors.

Findings for RQ3

Twelve key findings emerged to address RQ3 regarding drivers and barriers to implementing sustainable supply chain practices in this sector. They are summarised below but also shown in Figure 4.

1. The primary drivers and barriers regarding sustainability implementation in GCC petrochemical companies are noted in Figure 1.
2. Sustainability from respondents' viewpoints has different definitions, but these definitions reinforce findings discussed above about a lack of sustainability understanding. Also, definitions discussed were not comprehensive.
3. The mindset of leaders in the GCC region, whether belonging to companies or governments, is the most critical internal and external driver for sustainability, even more than regulations and sustainability costs. GCC leaders may amend regulations to avoid costs, even if such amendments may be detrimental to sustainability efforts. For example, one respondent noted that '*It is a mindset, sustainability requires a change in the mindset because it sometimes requires a change in how you do business. So, as a mindset it determines a long-term vision and I think it's driven by top management. They should drive it; they should own it*.'
4. In the GCC, most company respondents do not favour having a special department for sustainability. They believe sustainability must be embedded in the DNA of companies. When sustainability is limited to a department, costs will increase, and other departments may feel that they have nothing to do with it. Another respondent noted that '*It must be at a corporate level but also embedded in the DNA of each department. If you keep only the corporate function reporting to the CEO and the rest of the other businesses are disconnected from sustainability, you did not do it right. What we're doing here in our company is we have a sustainability target on business and functional levels*.'
5. In the GCC, partnerships with global companies have contributed enormously to the success of the Petrochemical sector, built a good culture, transferred knowledge, and enhanced sustainability. As one respondent put it '*Every business and maybe every company has different aspects than others. For example, if a company has new technology you may find many sustainability requirements already built in to do that technology in the factory. But when you were talking about refineries built in the 1950s or 1980s it is different. Generally, as countries or companies we do not work in isolation; we work as part of a system. Companies in KSA work under the regulations and requirements of the KSA government but at the same time, KSA is part of the world and so you'll find some of the targets and guidelines from agreements with international organisations where companies I remember*.'
6. In the GCC, government leaders are drivers of sustainability. For example, in KSA the government's Vision 2030 has transformed the country in many different ways, including the O&G industry, for a more differentiated and sustainable economy and including many sustainability initiatives. This has also changed many regulations, practices, and standards so that they are at the global level. Further, it has changed the government's mentality, making it more business orientated.
7. In a context unique to the GCC, due to the requirement for petrochemical companies to compete in global markets, the companies are much more developed regarding sustainability than governments. The companies regulate themselves as opposed to waiting for government enforcement, responding to coercive institutional pressures from customers and suppliers.
8. In recent years, governments have been essential to GCC sustainability, and not only for putting regulations in place. They have introduced new and updated standards, programmes and practices enhancing sustainability. This is due to changes in governmental leadership, the mindset of governments to be more business-oriented, and the development of various initiatives such as the KSA Vision 2030.

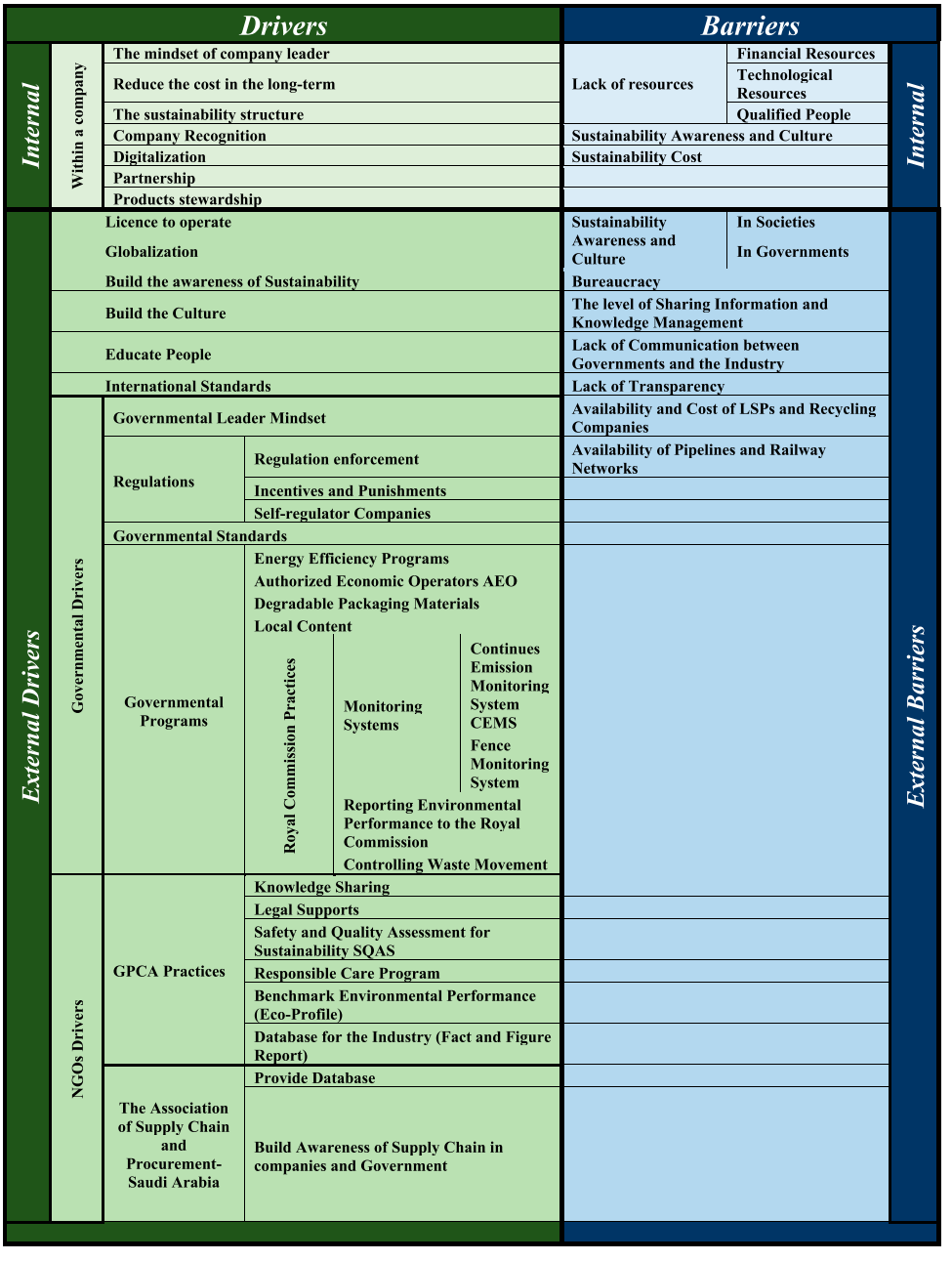

Figure 4. Sustainability drivers and barriers noted by respondents. Source: Authors.

9. In the GCC region, one of the significant barriers to sustainability is the level of awareness and a lack of knowledge. The NGOs are responsible for increasing sustainability awareness and knowledge and play a crucial role in dealing with this barrier through conferences, building databases, increasing awareness, publishing reports, and sharing knowledge and practices among the industry and governments. For example, one respondent noted that '*Governments should first understand their role in the implementation of sustainability, how and who is going to implement it, and that there should be change management programmes to prepare people for*

the implementation. The people should understand that this change is important and impacts on all of us. It is not only about penalties and punishments. You will never succeed by punishments; you'll only succeed by implementing a change management programme. After training and educating people, review the programme and make sure they consider it part of their daily working processes and that they understand its value for the firm.'

10. The GCC region is different from other parts of the world. Apart from qualified people, the cost and resources are not significant barriers. The main barriers, based on respondents' beliefs, are related to qualified people, awareness, and the culture of sustainability.
11. As sustainability awareness and culture are the two main external barriers, societies in the GCC region will accept paying a premium on prices for sustainability which is one indicator that the society is reaching a higher level of awareness and imbedding a culture of sustainability.
12. Governments in the GCC region must change management programmes to prepare people to understand the risks and adopt sustainability in everything. This could be achieved through enhanced education.

Discussion

Interview respondents noted that Benchmarking is a crucial practice for the sector's supply chains, in line with suggestions from Shaw, Grant, and Mangan (2010) and Gardas, Raut, and Narkhede (2019), but with not much widespread benchmarking happening outside the GCC region, in some cases even outside the company. In addition, globally recognised performance frameworks, such as the BSC or SCOR model are not widely adopted. Furthermore, no respondents gave indication they would benchmark, i.e. within or outwith the GCC region, nor if sustainability benchmarks were to be included. Thus, there is a need for companies in the GCC Petrochemical sector to consider the full ramifications of benchmarking for continuous improvement and to achieve best practice, and also alternative models and frameworks to enable a fuller appreciation of their overall and sustainability performance, like GRI, SDGs and therefore ESG performance dimensions. The sector appears to be driven more by normative and coercive institutional pressures from their customers and the government, which focus on more traditional performance measures of cost, value, time and accuracy. Less so on mimetic pressures, given the lack of benchmarking activity.

Respondents also believe the primary role of the supply chain is to create value for the business and not simply reduce costs – this was reinforced by their view to have partnerships with competitors for sourcing practices. In other words, economic stability and competition as external factors are important for this sector (Ahmad et al. 2016), but should be aligned with objectives for sustainability (Grant 2012; Grant, Trautrims, and Wong 2022). Thus, a key institutional pressure is the customer, and to create value ultimately for them. These external pressures consequently affect what measures are focused upon and how these organisations therefore respond and behave (i.e. RQ1 what best practices they employ, RQ2, what measures and reporting systems they adopt and RQ3, what drives or prevents them to behave in certain ways).

However, respondents also lack awareness of negative environmental effects from this sector, which is no different to findings from other authors (Bathrinath et al. 2021; Silvestre, Gimenes, and Neto 2017; and Cui et al. 2022). Hence, there is a role for increased training and education as well as industry seminars to raise and maintain the awareness of the importance of sustainability and its various effects on the petrochemical as well as external guidance from organisations such as GRI (2023), Agility (2023) and adoption of wider approaches such as ESG are critical to sustainability progression.

From a best sustainable supply chain measurement system and measure, the sector is focused on health & safety, as well as customer satisfaction, driven largely by pressure from the customer and government. While this focus is laudable, it is limited from a sustainability perspective and there needs to be more attention paid to other measures and systems of sustainability, in line with

Grant and Shaw (2019), and Shaw, Grant, and Mangan (2021) and the authors' compilation of important sustainability KPIs in Table 3. However, it is understandable that respondents might be confused when many of the major O&G companies are likewise confused over what to measure and report (Okeke 2021 Schneider et al. 2013;). Comments made above about further education and awareness also apply here. A key finding is that some of the metrics measured and reported by organisations can have dual roles and represent ESG metrics. For instance, 'reducing the number of accidents' (can be seen as a social measure from an ESG perspective or GRI) or reducing incidents of pollution (can be environmental as well as social from a health and safety perspective) (Tables 2 and 3). Thus, without realising it, many organisations in this sector are already measuring some elements of sustainability or ESG performance.

The important drivers and barriers regarding sustainability implementation in the GCC Petrochemical sector are noted in Figure 1 and should provide guidance for companies in this sector, as well as the GRI (2023) and Agility (2023) reports. However, respondents' trust in external stakeholders as well as how they would organise internally to deal with sustainability are lacking clarity and represent risk factors for their companies (Baryannis et al. 2019; Gurtu and Johny 2021).

IT was the theoretical underpinning focus for this work, and all three forms of isomorphism were found. There were elements of coercive isomorphism in terms of potential rules, regulations and penalties and punishments if they were not followed (i.e. governmental, SQAS regards pollution). Mimetic isomorphism came in the form of trying to establish benchmarks however that is not well developed as many respondents are not able to identify appropriate global benchmarks. Lack of benchmarking potentially inhibits progression around sustainability, continuous improvement and best practice for this sector. Finally, normative isomorphism was found in respondent professionalism in terms of wanting to do the best job for their customers, create value, and ensure the health & safety of their employees. While not a form of isomorphism as it is not a constraining force, beyond the normative view, self-regulation and partnerships were strong beliefs of respondents. The a priori view that coercive might outweigh the other two forms of isomorphism were not substantiated. A key finding and observation from the research is that the sector, without knowing it, is strong in some measurement areas of the 'S' in ESG, which is largely driven by key normative institutional forces (For example: health & safety measures and employer protection). The sector does also measure some elements of the 'E' in ESG, but these are still lacking holistically, when you compare and contrast Tables 2 and 3.

As noted previously, four overriding main themes or pillars emerged from the data analysis of discussions with respondents about best practice in response to RQ1: digitalisation, value creation, risk management, and partnership. Figure 5 summarises the four pillars and the key points are discussed below.

The first pillar, digitalisation is considered an important trend in supply chain and has become a central theme at many industry conferences. Respondents noted digitalisation is key for agility and rapid movement within the business world and supply chains. Respondents consider systems are also talking to each other and digitalisation is helping to speed the process of information transformation. Digital technologies are increasingly recognised as significant enablers of sustainability across various sectors. The integration of digital transformation (DT) strategies, such as Artificial Intelligence (AI), Big Data (BD), and the Internet of Things (IoT), have shown potential in enhancing sustainable practices, particularly in supply chains, and achieving Sustainable Development Goals (SDGs). For example Egbumokei et al. (2024) found AI technologies help predict equipment failures and enhance operational efficiency in this sector. Also, IoT devices and data analytics enable continuous and real time monitoring of energy consumption and emissions, allowing for adjustments to be made to operations.

The second value creation pillar, in addition to being the main role for supply chains as reported by respondents, is considered a strategic tool that will raise awareness of supply chains within companies and enable better decision making. Furthermore, respondents consider that value creation really needs creativity and some discussed establishing centres of excellence as one way of ensuring

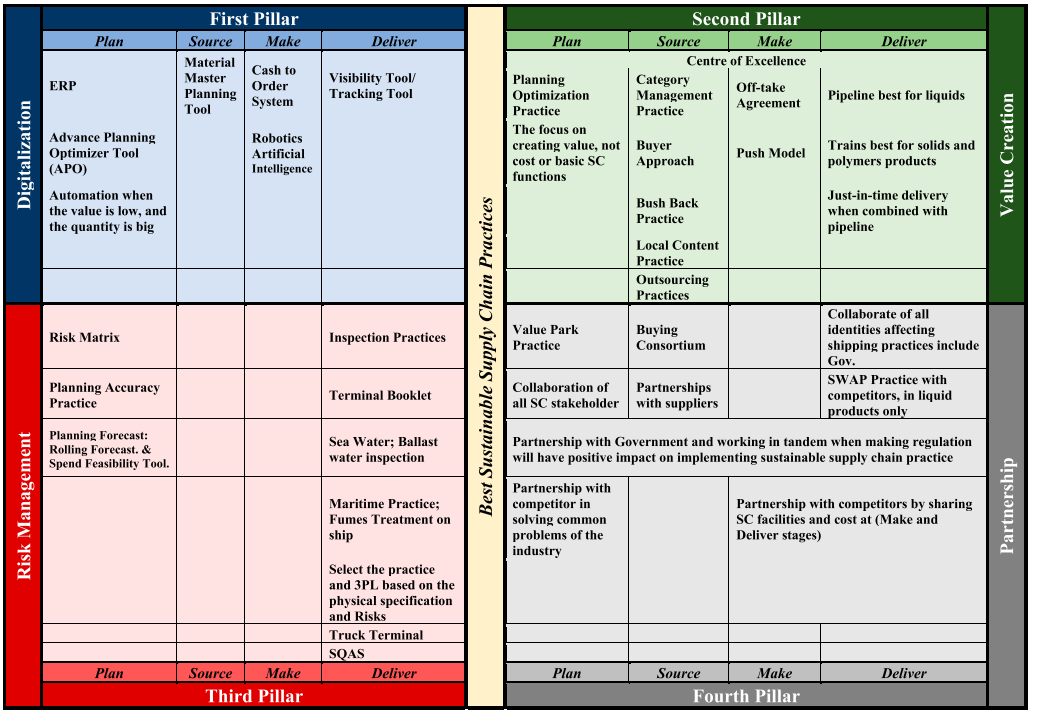

Figure 5. Four pillars noted by respondents emerging from data analysis. Source: Authors.

success and value creation in the supply chain. Some companies are already doing this and refer to employees working on continuous improvement and KPIs for business processes as an 'Excellence Team'.

Risk management is the third pillar, it has two elements: planning and delivery. Planning includes planning accuracy, forecasting practice, and feasible forecasts. Delivery includes maritime practice for safety at sea and treatment of fumes on ships, safety inspection practises such as ensuring teams are qualified and developing safety and quality assessment for sustainability (SQAS). Risk is an important part of ESG and sustainability and this could be viewed more strategically by the sector to enable it to adapt rapidly to a low carbon future to address the 'Sustainable Paradox' discussed in the introduction. Currently the predominant lens is operational risk and this needs to be more strategic risk, aligned with the Paris Agreement, SDGs and ESG.

The fourth and final pillar to emerge was partnership. This includes internal or intra-organisational partnerships for planning, sourcing including buyer consortiums, delivery from suppliers and customers, as well as external partnerships with government and competitors, including sharing facilities and supply chain services.

The Petrochemical sector in the GCC is built based on a partnership model with foreign partners. The acquisition of Saudi Basic Industries Corporation (SABIC) by Aramco in KSA has not only positioned Aramco as a major petrochemical player worldwide, but demonstrates the role partnerships play in the GCC region. Equally, Vision 2030 sets out Saudi Arabia as a global industrial hub, attracting foreign investment and fostering innovation in high-value industries. The Petrochemicals sector, with its vast potential for value addition, is a key component of this vision (Arab News 2024). These partnerships will undoubtedly play a fundamental role in the transition to a low carbon future, exploiting existing infrastructure to generate new energy production, such as green hydrogen and harness carbon capture.

Conclusions

Contributions to theory

To our knowledge, this is the first exploratory empirical study applying IT to sustainability in the GCC Petrochemical sector, viewed from the perspectives of the Petrochemical supply chain practitioners themselves. The study also identified best sustainability practices via the emergent four pillars of digitalisation, value creation, risk management, and partnership to address RQ1 and RQ2, and identified key drivers and barriers for implementing sustainability practices in the GCC to address RQ3.

The study informs IT, elements of all three institutional isomorphic pressures, coercive (internal and external pressures on companies), mimetic (a belief in benchmarking), and normative (professionalism and working with governments and NGOs including universities), all influence and impact the GCC petrochemical sector. However, normative and coercive are the predominant pressures in this sector . Linked to this, partnerships and self-regulatory practices emerged as important drivers for implementing sustainable supply chain practices beyond usual IT elements.

Contributions to practice

The emergent findings allowed the development of the four pillars and related KPIs to provide guidance for the GCC Petrochemical sector, and other O&G industry companies, governments and NGOs, regarding applying changes to extant business models to improve sustainability best practice. The GCC region, and sector, needs to prepare for a digital ecosystem after Industry 4.0 through integration.

The sustainability of supply chains in the Petrochemical sector is increasingly critical due to environmental concerns and the need for responsible resource management. This research indicates that while some progress has been made, significant gaps remain in the implementation, measurement and reporting of supply chain sustainability. All four pillars are inextricably linked, as there is a need to rapidly evolve, innovate and work with 'partners' and exploit the pillar of 'digitalisation', to create 'value' for customers and to reduce 'risk' for the sector and planet.

The sector needs to embrace internal and external benchmarking to accelerate sustainable supply chain best practices, and learn from other sectors. Adoption of frameworks such as the GRI, SDGs, CSRD or ISO's ESG Implementation Principles (ISO 2024: IWA 48:2024), will provide a guide to implementing and embedding ESG and sustainability and the correct measures and frameworks. This will ensure that the sector is aligned with key global targets, such as the Paris Agreement and SDGs. Leadership and culture within the sector is key, and was recognised by the respondents themselves as critical to sustainable transformation.

Contributions to policy

Eight policy recommendations are suggested for governments to enhance sustainability implementation including inter alia fostering local content, building a sustainability culture led from the top, improving bureaucracy, and building supply chain infrastructure networks among GCC countries. The government, NGOs and Royal Commission can play a central role in enforcing globally recognised frameworks like those outlined above (GRI, ISO, SDGs and CSRD). Embracing digital and this institutional pressure to implement and accelerate supply chain sustainability within the Petrochemical sector in the GCC region is critical, along with addressing the skills and knowledge gap.

Limitations and future research

As with all studies, there are a few limitations that provide an opportunity for further research. Firstly, the study comprised a small sample from one sector, petrochemical companies and relevant

stakeholders, in the GCC region, limited to KSA, Kuwait and UAE. While the results are valid for this context, they are not necessarily generalisable to others. Use of one singular method, such as interviews can bring bias, therefore we suggest future studies could apply a mixed method approach, combining quantitative methods to improve external validity. Future research should expand the scope of study to other regions, such as Qatar, North America, Southeast Asia, other Middle East and African countries, and Russia, to test the four pillars and sustainability best practices and KPIs found in this research. Secondly, this study's methodology and methods could also be applied to other industries and sectors (such as comparing pharmaceutical sector to this sector), to see if results are consistent which might lead to a more homogeneous sustainability measurement techniques and scales.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Data availability statement

Due to the nature of this research, participants of this study did not agree for their data to be shared publicly, thus supporting data is not available.

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Appendices

Appendix 1. Interview protocol & questions for companies

The Questions

1. Describe the department of supply chain in your company?
   - ☐ How many divisions (components) and what are they?
   - ☐ The main functions and responsibilities.
   - ☐ Reported to whom?
   - ☐ The importance of this department in your company
2. In your company, which department/s is/are dealing with sustainability issues?
   - ☐ The main roles of each department in implementing sustainability.
   - ☐ What perspectives are more important in relation to sustainability and SC? Why?
     - Environmental Perspectives
     - Social Perspectives
     - Economic Perspectives
3. Which, in your opinion, are the most appropriate sustainable supply chain practices that should be used by the petrochemical companies in the GCC? Why?
4. What framework, tools or techniques does your company use to measure its supply chain performance? Why? Are the sustainbility perspectives considered during measuring and reporting performance?
   - ☐ Advantage and Disadvantage of the method.
   - ☐ The critical elements to be measured.
5. Please put the following factors in order of importance in terms of their impact on sustainble supply chain performance measurement in your company?

The Factors	The order
Organisational Culture.	
People	
Process of measurement Systems of measurement	
The culture of the country. Other factors to add	

6. What are the internal and external barriers and drivers to implement sustainable supply chain practices in your company? And what is the effect of the following factors:
   - ☐ Government
   - ☐ Culture
   - ☐ Resources (Finanical, Peope and Technology)
   - ☐ Government/ Regulations
   - ☐ Applying intensives and Punishment
7. When do you think that your company should take the decision of benchmarking with other firms? And do you think benchmark is an effective managerial tools to be used when the company uncertain about any issues and why?

8. In terms of supply chain, what are the cases that your company decided to benchmark with other companies?
    a. Why should they take such decisions?
    b. In your opinion, what are the advantages and disadvantages of benchmarking?
9. Do you think the non-governmental associations such as GPCA should work with the large companies such as SABIC to develops standards and identify the best sustainable supply chain practices, and make the outcome of their work available for smaller petrochemical companies for benchmarking?
    a. What advantages and disadvantages can be achieves from such initiatives?
10. Do you think there is a lack of qualified people in implementing sustainable practices in your company?
    a. If yes, what could be done by your company to deal with this issues?
    b. Do you think your company should recruit qualified staff from other petrochemical companies to deal with sustainability when they are uncertain about the right practices?
    c. Are there any initiatives, guidance or training should be provided by governmental or non-governmental organization to help your company in dealing with this issue?
11. Do you think (universities), professional networks, training institutions and associations are important sources to enhance the professionalization level in implementing sustainability or it is easier to benchmark sustainable practices with one of leading companies from petrochemical industry?
12. Do you think (coordinating/ partnership) with supplier or customers can play rules in implementing sustainable practices?
    - Why and how?
13. How do you see the effect of the pressures that come from governmental and non-governmental organizations to implement sustainable practices? Do you think this pressures is important to implement sustainable practices? Or your company is taking initiatives to implement sustainability without such pressures?

    For example, The GCC council in his 6th session in Muscat Summit (1985) adapted document of "The Policies and General Principles of Environment Protection at the GCC States" is such policies effecting or forcing your company to implement sustainability?
14. Do your company implement the standard of Environment, Health, Safety and Security (EHS&S) and other international environmental standard produced by any governmental or non-governmental organizations such as GPCA? Or do your companies have their own standards? Why?
15. Do you think the GCC council should monitor and give the guidance to businesses in general to implement certain standards to deal with environmental and social issues?
16. In your opinion, who and why are the most powerful players in the petrochemical industry; governments, non-governmental organisation, customers, suppliers or big companies?
17. Which of the following do you think is more effective to be used by petrochemical companies in the GCC to implement sustainble practices;

- Benchmarking the practices with leading or big company.
- Recuite qualified people in sustainbility form other petrochemical companies.
- Follow detailes guidacne or standard designed by other govenmental or non-governmental organisation.

Appendix 2. Interview protocol & questions for experts, government and non-governmental organisations

The Questions:

1. In your opinion, what is the importance and the role of Supply Chain department in Petrochemical Companies in GCC?
    a. How many divisions (components) should this department be divided into?
    b. What are the main functions of these divisions?
2. What is the importance and the role of Sustainability department in the Petrochemical Companies in the GCC?
    a. What, in your opinion, are the most appropriate sustainable supply chain practices should be used the petrochemical companies in the GCC?
    b. Why do you think they are effective and should be used?
3. What framework, tools or techniques you recommended to be used by the Petrochemical companies in the GCC to measure its supply chain performance and sustainability performance? Why? And how they should report the results and to whom?
    - ☐ Advantage and Disadvantage
    - ☐ The critical dimensions/ elements to measure
4. Most of performance measurement systems are focusing on measuring internal factors such as the Revenue, Return on Investment or total supply chain cost. Do you think it is important (and why) to measure the external factors such as the relationship with suppliers or with customers, the efficiency of suppliers, for example, in delivering on the right time, right place and right price?
5. What are the critical sustainability issues should be covered in the performance measurement system in the petrochemical companies in the GCC? Why do you think they are important?
6. What are the internal and external barriers and drivers to implement sustainable SC practices amoung Petrochemical Companies in GCC ? And what is the effect of the following factors:
    - ☐ Government
    - ☐ Culture
    - ☐ Resources (Finanical, Peope and Technology)
    - ☐ Government/ Regulations
    - ☐ Applying intensives and Punishment
7. When do you think that petrochemical companies in the GCC should take the decision of benchmarking with other company?
    a. In your opinion, what are the advantages and disadvantages of benchmarking?
    b. Do you think benchmark is an effective managerial tool to be used when the company uncertain about any issues and why?
8. What do you think about the rule of GPCA in encouraging and promoting supply chain best practices, policies, standards, benchmarks and measuring their impact of petrochemical industries?
9. Do you think the non-governmental associations such as GPCA should work with the large companies such as SABIC to develops standards and identify the best sustainable

supply chain practices, and make the outcome of their work available for smaller petrochemical companies for benchmarking?

a. What advantages and disadvantages can be achieves from such initiatives?

10. Do you think there is a lack of qualified people in implementing sustainable practices?

a. If yes, what could be done by the companies to deal with this issue?

b. Do you think petrochemical companies should recruit qualified staff within same industry to deal with sustainability when they are uncertain about the right practices?

c. Are there any initiatives, guidance or training should be provided by governmental or non-governmental organization to help those companies in implementing sustainability?

11. Do you think (universities), professional networks, training institutions and associations are important sources to enhance the professionalization level in implementing sustainability or it is easier to benchmark sustainable practices with one of leading companies from petrochemical industry?

12. Do you think (coordinating/ partnership) with supplier or customers can play rules in implementing sustainable practices? Why and how?

13. How do you see the effect of the pressures that comes from governmental and non-governmental organizations to implement sustainable practices? Do you think this pressures is important to implement sustainable practices? Or companies should be taken initiatives to implement sustainability without such pressures?

    For example, The GCC council in his 6th session in Muscat Summit (1985) adapted document of "The Policies and General Principles of Environment Protection at the GCC States" is such policies effecting or forcing petrochemical companies to implement sustainability?

14. Do you think that petrochemical companies in the GCC are implementing the standard of Environment, Health, Safety and Security (EHS&S) and other international environmental standard produced by any governmental or non-governmental organizations such as GPCA? Or do you think those companies should have their own standards? Why?

15. Do you think the GCC council should monitor and give the guidance to businesses in general to implement certain standards to deal with environmental and social issues?

16. In your opinion, who and why are the most powerful players in the petrochemical industry; governments, non-governmental organisation, customers, suppliers or big companies?

17. Which of the following do you think is more effective to be used by petrochemical companies in the GCC to implement sustainble practices;

    - Benchmarking the practices with leading or big company.
    - Recuite qualified people in sustainbility form other petrochemical companies.
    - Follow detailes guidacne or standard designed by other govenmental or non-governmental organisation.

Appendix 3. Interviewee profile

Respondent	Classification	Company or Type (LSP or Petrochemical company?)	Job Role	Location
1	Expert	Large Petrochemical company	Vice President VP-Supply chain	Saudi Arabia
2		LSP	Owner and CEO	Saudi Arabia
3		NGO	General Secretary	Saudi Arabia, United Arab Emirates
4		Large Petrochemical company And NGO	Director Supply chain CEO for the NGO	Saudi Arabia
5		Large Petrochemical company	CEO	Saudi Arabia
6		Large Petrochemical company	VP supply chain	Saudi Arabia
7		Large Petrochemical company	EVP supply chain	Saudi Arabia
8		Large Petrochemical company	VP supply chain	Saudi Arabia
9		Large Petrochemical company	CEO	Kuwait
10		Large Petrochemical company	VP shared services	Saudi Arabia
11		Large Petrochemical company	Director- supply chain	Saudi Arabia
12		Large Petrochemical company	CEO	Saudi Arabia
13	Employee	Large Petrochemical company	Manager-Warehousing	Saudi Arabia
14		Large Petrochemical company	Manager – supply chain	Saudi Arabia
15		Large Petrochemical company	Manager of Global sourcing	Saudi Arabia
16		Large Petrochemical company	Manager – logistic	Saudi Arabia
17		Large Petrochemical company	Director of supply chain	Saudi Arabia
18		Medum LSP	Manager - offshoring	Saudi Arabia
19		Large Petrochemical company	Manager- logistic	Saudi Arabia
20		Large Petrochemical company	Director of supply chain	United Arab Emirates
21		Large Petrochemical company	Manager- warehousing	Saudi Arabia
22		Government	Manager- environment	Saudi Arabia

23		Medum Petrochemical company	Director- supply chain	Saudi Arabia
24		Large Petrochemical company	Manager- Performance	Saudi Arabia
25		Large Petrochemical company	Manager- supply chain excellence	Saudi Arabia
26		Medum Petrochemical company	Manager- supply chain	Saudi Arabia
27		Medium Petrochemical company	Manager- Logistic	Saudi Arabia
28		Large Petrochemical company	Director – supply chain	Saudi Arabia
29		Large Petrochemical company	Director – Supply chain	Saudi Arabia
30		Large Petrochemical company	General Manager	Saudi Arabia
31		Government	Manager- – environment	Saudi Arabia
32		Large Petrochemical company	Manager Procurement	Kuwait