UNIVERSITY OF PLYMOUTH

SUPPLY CHAIN FINANCIAL PERFORMANCE IN LIQUEFIED NATURAL GAS SYSTEMS

by

NASIRU ZUBAIRU

A thesis submitted to the University of Plymouth
in partial fulfilment for the degree of

DOCTOR OF PHILOSOPHY

Plymouth Business School

July 2019

Copyright statement

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Dedication

This thesis is dedicated to my Son, Abdulsalam, who spent a couple of years away from his father to enable me to pursue this degree. I am deeply sorry for the time we spent away from each other.

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First, I would like to express my utmost gratitude to almighty God for giving me the patience, strength and wisdom to complete this work.

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Author's declaration

At no time during the registration for the degree of Doctor of Philosophy has the author been registered for any other University award without prior agreement of the Doctoral College Quality Sub-Committee.

Work submitted for this research degree at the University of Plymouth has not formed part of any other degree either at the University of Plymouth or at another establishment.

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A programme of advanced study was undertaken, which leads to the award of Post Graduate Certificate in Research Methodology.

Papers presented or published arising from this Doctor of Philosophy are included in List of publications section.

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Abstract

Supply Chain Financial Performance in Liquefied Natural Gas Systems

Nasiru Zubairu

Liquefied natural gas (LNG) is a rapidly growing energy source, with highly competitive supply chain networks, sensitive to global macro-economic developments. To date, supply chain finance studies have failed to explore supply chain financial performance (SCFP) in the LNG sector and few have demonstrated the potential impact of supply chain practices on financial performance. This study aims to evaluate the relationship between supply chain strategies and the financial performance of Nigeria liquefied natural gas (NLNG) systems, to guide practitioners to review and adopt supply chain initiatives that drive business survival and growth, while creating value for investors.

To identify key supply chain strategies that have financial influences for NLNG networks, SCFP related publications between 1999 and 2018 alongside interviews with experts and key decision-makers at NLNG were analysed using template analysis. To prioritise the relative influence of the major supply chain initiatives that drive financial performance in NLNG systems, supplementary data collected from NLNG was analysed using analytical hierarchy process (AHP).

In study phase one, qualitative template analysis of literature identified sourcing strategy, information technology and automation, integration and collaboration, and sustainability as key drivers of SCFP in NLNG systems. These drivers are measured using cost, revenue, working capital and assets utilisation. In study phase two, AHP presented integration and collaboration as the most important drivers of financial performance in NLNG networks, followed by sourcing, IT and automation, and sustainability. Study phase three identified investment and capacity development in addition to the four supply chain capabilities established earlier. Effective implementation of these initiatives is essential to realise the full financial advantages of effective supply chain strategies.

Theoretical and empirical taxonomies and frameworks facilitate understanding of how supply chain initiatives contribute positively to NLNG financial performance, and support practitioners in making strategic supply chain decisions. The AHP model provides a novel ranking for supply chain strategies and measures to guide decision-makers.

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List of publications arising from this study

Zubairu, N., Dinwoodie, J., Hunter, L., Roh, S. and Kumar, S. (in review), "Supply chain initiatives as drivers of financial performance in liquefied natural gas networks", *Journal of Purchasing and Supply Management.*

Zubairu, N., Dinwoodie, J., Roh, S., Hunter, L. and Umaru, S. (accepted), "Supply chain initiatives: antecedents for liquefied natural gas supply chain financial performance", *Logistics Research Network Conference (LRN 2019),* University of Northampton 4-6 September 2019.

Zubairu, N. (2019), "Impact of supply chain capabilities on LNG financial performance", *LNG Bunkering Summit*, Amsterdam 29-31 January 2019.

Zubairu, N. (2018), "Supply chain management capabilities: drivers of liquefied natural gas financial performance", *Joint MLBP & ProSerV PhD Seminar*, 13 December 2018.

Zubairu, N. (2018), "Improving liquefied natural gas financial performance through prioritising supply chain initiatives", *Small-Mid Scale LNG Summit,* Amsterdam, 03 October 2018.

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Khoury, B. and Zubairu, N. (2018), "Barriers to inventory management in humanitarian logistics: A Syrian supply chains study", *Logistics Research Network Conference (LRN 2018),* University of Plymouth 5-7 September 2018. DOI: https://ciltuk.org.uk/LRNfullpapers

Zubairu, N., Dinwoodie, J., Hunter, S. and Roh, S. (2018), "Supply chain financial performance in Nigerian liquefied natural gas industry", *13th University of Plymouth Faculty of Business Doctoral Conference (UPFoBDC 2018),* 25-26 June 2018. DOI: https://www.plymouth.ac.uk/uploads/production/document/path/13/13394/Business_Doctoral_Conference_2018.pdf

Zubairu, N. (2017), "Optimising financial performance in the liquefied natural gas supply chains", *Maritime and Logistics, Business and Policy (MLBP) PhD Seminar*, 15 December 2017.

Zubairu, N. (2017), "Liquefied natural gas as marine fuel: Just a dream or future reality?" *UK Plymouth Doctoral Colloquium (UKPDC),* 5-6 June 2017. DOI: https://www.plymouth.ac.uk/uploads/production/document/path/10/10990/UKPDC_2017_Proceedings.pdf

List of acronyms

λ	Lamda
°C	Degree Celsius
°F	Degree Fahrenheit
3PL	Third-party logistics
4PL	Fourth-party logistics
A:	Alternatives in analytical hierarchy process
AfDB	African Development Bank Group
AHP	Analytical hierarchy process
B	Billion
bbl	Barrel of crude oil
Bcf/d	Billion cubic feet per day
BGT	Bonny Gas Transport Company Limited
Boil-off	LNG volume that is evaporated during shipment
BP	British Petroleum
C:	Criteria in analytical hierarchy process
C2C	Cash-to-cash cycle
CAMA	Company an Allied Matters Act
CAPEX	Capital Expenditure
CEO	Chief Executive Officer
CI	Consistency index
CO_2	Carbon Dioxide
COA	Contract of affreightment
CR	Consistency ratio
CSCMP	Council of Supply Chain Management Professionals
CSR	Corporate Social Responsibility

DES	Delivered ex-ship
DFDE	Duel fuel diesel electric LNG carrier
DNV GL	Det Norske Veritas Germanischer Lloyd
DRC	Destination restriction clause
E:	Electronic
EBIT	Earnings before interest and tax
EDI	Electronic data interchange
EIA	US Energy Information Administration
ERP	Enterprise resource planning
EVA	Economic value-added
FEED	Front-end engineering and design
Feedgas	Gas feedstock
FERC	Federal Energy Regulatory Commission
FDI	Foreign direct investment
FID	Final investment decision
FOB	Free on board
FRSU	Floating storage regasification unit
ft^3	Cubic feet
GDP	Gross domestic product
GIIGNL	International group of liquefied natural gas importers
GTS	Gas transmission system or pipeline
HSE	Health, safety and environment
HSSE	Health, safety, security and environment
IEA	International Energy Agency
IGC	International Gas Carriers Code
IGU	International gas union

IMO	International Maritime Organisation
IOC	International oil company
ISO	International Standardisation Organisation
IT	Information technology
JCC	Japan customs-cleared crude oil price
JIT	Just in time
JV	Joint venture
K	Thousand
kkm^2	Thousand square kilometres
km	Kilometres
KBV	Knowledge-based-view
LNG	Liquefied natural gas
LNG-IRP	LNG inventory routing program
LTC	Long-term contract
M	Million
m	Metres
m^3	Cubic metre
MCDM	Multi-criteria decision-making
MCE	Probabilistic Maximum Considered Earthquake
MD	Managing Director
MoU	Memorandum of Understanding
Mtpa	Metric tonne per annum
Mt	Metric tonne
NBS	National Bureau of Statistics
NGL	Natural gas liquids
NLNG	Nigeria liquefied natural gas limited

NNPC	Nigerian National Petroleum Corporation
NOC	National oil company
NOGICD	Nigerian Oil and Gas Industry Content Development Act
NPA	Nigerian Ports Authority
NPV	Net present value
NSML	NLNG ship management limited
OKLNG	Olokola LNG
OPEC	Organization of the Petroleum Exporting Countries
OPEX	Operating expenditure
p.a.	Per annum
PIB	Petroleum Industry Bill
PIFB	Petroleum Industry Fiscal Bill
PIGB	Petroleum Industry Governance Bill
RBV	Resource-based view
RFID	Radio-frequency identification
RI:	Random index
ROA	Return on assets
ROE	Return on equity
ROI	Return on investment
ROS	Return on sales
SCF	Supply chain finance
SCFP	Supply chain financial performance
SCM	Supply chain management
SCOR	Supply chain operations reference model
SECA	Sulphur emission control areas
SPV	Special purpose vehicle

T	Trillion
t	Tonnes
TBEI	Text-based electronic interview
TCE	Transaction cost economics
TQM	Total quality management
Triple A:	Agility, adaptability and alignment
UAE	United Arab Emirates
UK	United Kingdom
UNGC	United Nations Global Compact
US	The United States
USCG	the US Coast Guard
USD	United States Dollars

Chapter one: Introduction

1.1 Chapter one overview

This chapter presents an overview of this study: *Supply chain financial performance in liquefied natural gas systems*. The chapter begins with a general background regarding developments in the energy industry, with specific focus on the liquefied natural gas (LNG) sector in the Nigerian context. The research problem is stated and the research gap is introduced. The ensuing research question and objectives guide the direction of this study and the research methodology outlines how the research objectives are accomplished. This chapter ends by setting out the layout of the thesis and presenting a brief description of each chapter.

1.2 Background

The desire for low-carbon fuels and reduced CO_2 emissions is driving the global demand for natural gas as an energy source (Lam *et al.,* 2015; Kainuma *et al.,* 2013; Khalilpour and Karimi, 2011). Oil, natural gas and coal remain the dominant sources of energy powering the global economy, which will account for over three-quarters of total energy supplies by 2035. However, increasing at 1.6% p.a., natural gas is the fastest growing primary energy source (BP, 2017). Natural gas is projected to overtake coal to become the second-largest fuel source by 2035. Oil will continue to grow at 0.7% p.a., although its growth is expected to slow gradually, while the growth of coal is projected to decline sharply to 0.2% p.a. compared with 2.7% p.a. over the past two decades (BP, 2017). Further, the development of the United States (US) shale gas and the rapid expansion of LNG is likely to lead to a globally integrated gas market, which will support the LNG rapid growth (BP, 2017).

Transporting natural gas in its natural form over long distances is very expensive and the most efficient way of transporting gas is by liquefaction into LNG, which involves natural gas being converted into a liquid state (GIIGNL, 2014b; Özelkan *et al*., 2008). This involves cooling at temperatures below -162°C. In this form, it occupies 600 times less space, while retaining the same calorific value (GIIGNL, 2014a; Supply chainheig, 2009). Although pipelines are the major delivery system in global natural gas trade, and are very cost efficient over short distances, this is not technically feasible or economically viable between suppliers and customers in different continents. In such situations, natural gas is transported in the form of LNG, using special ocean-going vessels (Mutlu *et al.* 2016; Raju *et al.*, 2016; Özelkan *et al*., 2008), hence making its supply chain longer and more complex. A typical LNG supply chain is made-up of exploration, treatment, gas transportation, production/liquefaction, storage, shipment, regasification and distribution (Mutlu *et al.* 2016; Özelkan *et al*., 2008).

As the world's economies are turning to natural gas, the demand for LNG will continue to grow (Lam *et al.,* 2015; Jokinen *et al.,* 2015). More and more economies, industries and households recognize many advantages of using LNG, including reduced CO_2 emissions, improved air quality, easier transportation, better accessibility and multipurpose usage in various sectors, among others (Nikhalat-Jahromi *et al.,* 2016). This is an exciting time for LNG networks such as Nigeria LNG (NLNG) supply chains; however, LNG supply chain participants seeking to enhance their competitive advantage must understand initiatives that improve performance (Andersson 2016; Özelkan *et al.,* 2008).

Since the 2008 global financial crisis, substantial reductions in issuance debt and increased financial costs have squeezed corporate liquidity (Ivashina and Scharfstein, 2010). Subsequent initiatives and solutions to optimise financial flow have embraced supply chain finance (SCF) strategies (Caniato *et al.,* 2016; Polak *et al.,* 2012). Businesses are continually seeking strategies to improve their supply chain performance to reduce costs and downtime, to improve their productivity and customer base, and become more sustainable. As executives realise that supply chain competition has now ousted corporate competition, a well-managed supply chain offers a gestalt in which the value of the whole exceeds the sum of its parts. SCF supports the financial flow, which enables network participants to improve working capital and reduce costs (Zhong, *el al.,* 2018; Templar *et al*., 2018; Wuttke *et al.,* 2013b). The benefits of the SCF approach rely on cooperation among the supply chain participants to minimise cost of debt, explore new avenues for obtaining loans, or reduced working capital within the supply chain. The SCF approach often improves trust, commitment, and profitability across networks (Randall and Farris, 2009). Indeed, any supply chain management (SCM) strategy should ultimately aim to optimise SCFP (Shi and Yu, 2013).

1.3 Nigerian case study

Nigeria is the most populous country in Africa with a population of around 198M in 2017 (OPEC, 2018). Nigeria's population is growing at 2% p.a., which exceeds rates in the other 13 members of the Organization of Petroleum Exporting

Countries (OPEC). Located on the Gulf of Guinea on Africa's western coast, Nigeria covers an area of 924kkm^2. English is Nigeria's official language, although many local languages such as Hausa, Yoruba and Igbo are also spoken (OPEC, 2018; 2017). Nigeria's economy continued to show signs of recovery from the 2016 recession. The outlook for the medium term is positive with the economy projected to grow at 2.1% and 2.0% in 2018 and 2019 respectively. This projection is underpinned by improved petroleum production and stronger agricultural performance (AfDB, 2018). Oil and gas has been a major contributor to the Nigerian economy (Oti and Odey, 2016; Akinlo, 2012; Odularu, 2008). A 2018 report by the National Bureau of Statistics (NBS) revealed that despite the efforts of the Nigerian Government to diversify the economy, exports from the oil and gas sector still account for 81% of the country's total export earnings. This demonstrates the strong influences of oil and gas for Nigeria's economy.

Nigeria is ninth in the world and first in Africa in terms of proven reserves of natural gas (BP, 2018a; 2016). To harness this vast natural gas resource, the NLNG was incorporated on May 17 1989 and had its maiden production from NLNG Train 2 on September 15 1999 (NLNG, 2018a; 2017). NLNG has generated significant revenues for the country. NLNG is one of the most important economic projects in Nigeria. Major contributions of NLNG to the Nigerian economy includes gas monetisation, generation of foreign direct investment (FDI), increase in gross domestic product (GDP), environmental hazard reduction, job creation, local content development and corporate social responsibility (CSR) programs (NLNG 2018b).

NNLG harnesses gas that is flared otherwise (Adekomaya *et al.,* 2016), earning income for the nation while helping to protect the environment. Payment to feedgas suppliers from inception to 2018 is about USD 24B, in which 55-60% of such payment goes to the Federal Government of Nigeria via its shareholding in Nigerian National Petroleum Corporation (NNPC). So far, NLNG has paid dividends of over USD 33B, of which 49% went to the Federation account due to its shareholding in the company via NNPC. NLNG also contributes to the states in which it operates through payments of applicable taxes and tariffs. In 2017, NLNG corporate income tax paid to the Federal account amounted for USD 606M (NLNG, 2018b), from 323 paid in 2016 (NLNG, 2017). NLNG contributed over 12% of government revenue in taxes and dividends in 2014 and 2015; with revenue exceeding USD 90B since inception (NLNG, 2018; 2017).

These are welcome developments for the Nigerian gas sector and the economy at large. Nigeria had 5.2 Tm^3 of proven natural gas reserves in 2017, which accounts for 2.7% of world proved reserves (BP; 2018; 2016). However, for a decade, Nigeria has averaged fourth position in terms of LNG export, and the country has failed to grow over this period. Since 2015, Nigeria has not even maintained its position steady, thereby surrendering its competitive edge as a major LNG exporter (Clarksons, 2017; 2016). Nigeria’s natural gas sector is constrained by the lack of infrastructure to fully commercialise its natural gas resources (EIA, 2016) and the country has failed to attract significant investment to develop new LNG facilities (Clarksons, 2016). Qatar, a major LNG exporter, US a new exporter, and Australia, a relatively new and the fastest growing LNG producer, are expected to dominate the LNG market for the next 20 years (GIIGNL, 2017; Glarksons, 2016; IGU, 2017). Although Nigeria has more proven reserves than some of its competitors in the LNG industry (BP, 2016), in 2017 Nigeria exported only 20.34 Mt, which exceed Indonesia’s exports but is surpassed by the other three major exporting countries: Qatar, Australia and Malaysia (GIIGNL, 2018). This low ranking can be addressed through careful review and implementation of SCF strategies, which this study examines. Emerging studies strengthen the links between SCM practices and corporate financial performance (Martin and Patterson, 2009). SCF is a SCM solution that optimises financial flow within and across supply chains (Caniato *et al.,* 2016; Polak *et al.,* 2012).

1.4 Problem statement

The energy market is highly competitive and sensitive to global macro-economic trends, political developments, and technological advances, and thus highly volatile. Moreover, LNG suppliers must cope with changing contractual terms and fluctuating prices, while investing in additional production and transportation capacities (OPEC, 2016; Berle *et al.*, 2011; Özelkan *et al.,* 2008). In the coming years, the LNG market will face various global developmental challenges, which will occur due to the growth in demand for LNG from Southeast Asia and other regions. The industry will have to meet the needs of buyers and work on improving LNG infrastructure, adhering to changing policies and embarking on new projects (Andersson 2016; Özelkan *et al.,* 2008). Investment decisions in LNG supply chain involve a significant trade-off between risk and returns by investors (Furlonge, 2011). Uncertainty is a key concern for initial investment into natural gas supply chains (Abadie and Chamorro, 2009). As a result, LNG operators are continually looking for strategies to improve their financial performance thereby cutting costs and downtime, improving productivity and customer base, as well as achieving sustainability in the long-run. Christopher and Jüttner (2000) envisaged that in the future, real competitive advantage would stem from supply chains as a whole rather than the individual companies. More recently Shi and Yu (2013) posited, that there is a growing recognition among business executives that today's business competition is no longer between individual companies, but between supply chains. If a supply chain is well managed its whole value can be greater than the sum of its parts. As a result, the need to structure SCM into overall business strategy development becomes ever more apparent (Christopher and Jüttner, 2000).

Managers need to know whether SCM practices contribute to financial performance, and how to direct investments to enhance competitive advantages and maximise value for investors (Zubairu *et al.,* 2018). To justify supply chain strategy, managers are obliged to show how strategies contribute to financial results (Shi and Yu, 2013). Strategy formulation incorporates critical performance measurement, but few studies have investigated SCF drivers and measures. Fragmented prior studies have considered performance drivers or measures. To date there is only one prior statement that explicitly presented a combination of SCM competencies that drive financial performance, including *sourcing strategy, technology, system integration and external relationships*, measured by *revenue, cost and working capital* (Shi and Yu, 2013).

1.5 Research gap

Aside from a SCF study by Shi and Yu (2013), all other articles study the relationship between supply chain strategy and financial performance using disjointed drivers such as integration and information sharing or human resource or technology. Some publications presented only the supply chain measuring criteria, including revenue, cost, working capital, assets and taxation, without showing combinations of the supply chain capabilities that drive financial performance (Cristopher, 1998; Christopher and Ryals, 1999). This study identifies drivers and measures for SCF and devises an updated taxonomy of supply chain financial performance (SCFP) to guide researchers and practitioners in the design and implementation of supply chain strategies that drive financial results.

Despite the increasing relevance of the LNG industry as the fastest growing industry in the energy sector and the role of LNG towards the building and sustainability of nations, LNG supply chains face many challenges. This study found no previous work that has explored, measured and defined SCFP in the LNG sector or in the energy market. In addition, the majority of SCM and SCF empirical research is conducted within European, Asian, and American contexts, leaving a dearth of SCF related studies framed within an African perspective. These are significant research gaps, which this study addresses.

Many researchers avoid conducting extensive studies in the energy sector due to competitiveness and sensitivity of the industry. Notwithstanding, because this research concerns supply chain strategy, the study pursues a feasible yet rigorous approach to data collection by conducting text-based electronic interviews (TBEI), and surveys that targeted strategic decision-makers. Relevant qualitative and quantitative data are collected from the case study to discover new understandings, meanings and insights regarding SCFP in NLNG systems. This combination is not a common practice in SCF studies, in which the two regularly used approaches for data collection are surveys and archived secondary data (Shi and Yu, 2013).

In addition to the above research gaps, this study employs a novel design for data analysis by combining analytical hierarchy process (AHP) and template analysis over three phases as outlined in section 1.9.

1.6 Research question

In the light of the research gaps identified and the importance of SCFP to business survival and growth as well as value creation, this study aims to address the key question of: *how can operators in NLNG systems improve SCFP?*

1.7 Research objectives

This study proposes the following objectives to address the research question:

1. To identify the characteristics of LNG supply chain systems
2. To analyse the objectives of SCM in LNG distribution systems
3. To synthesise strategic drivers, capabilities and measures of SCFP
4. To assess the SCFP capabilities in NLNG systems
5. To develop a taxonomy that defines SCFP in NLNG networks
6. To propose strategies and policies to improve SCFP in NLNG systems

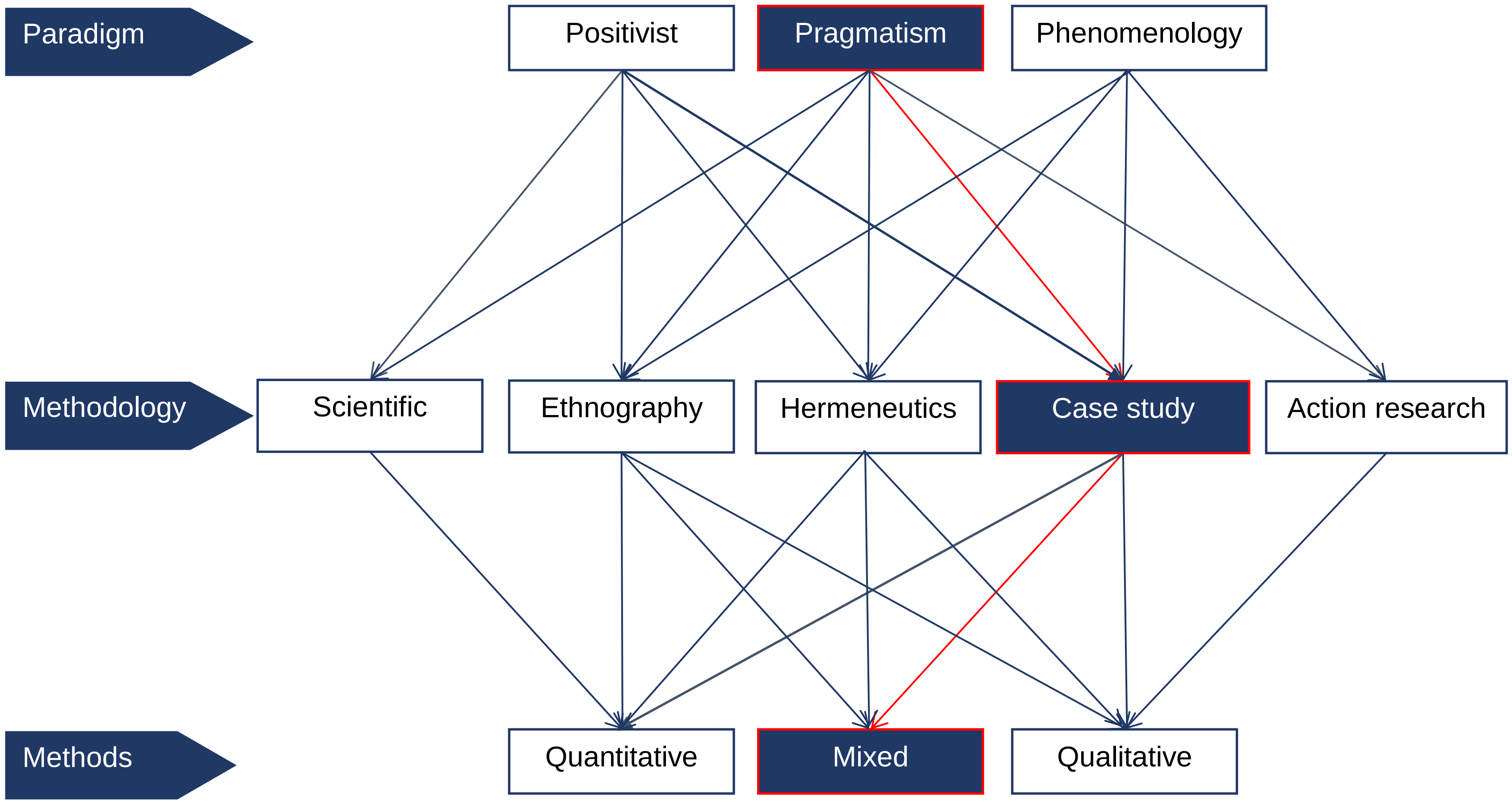
1.8 Research methodology

Methodology is the process of conducting research (Saunders *et al.*, 2016; Howell, 2013) whereas research methods define various techniques to collect and analyse data (Wilson, 2014; Howell, 2013).

The taxonomy and conceptual framework of SCFP in NLNG systems incorporates transaction cost economics (TCE), and theories emanating from resource-based views (RBV) and knowledge-based views (KBV). A case study methodology (Creswell and Poth, 2018; Merriam and Tisdell, 2015; Mertens, 2015; Yin, 2014; Denzin and Lincoln, 2011; Dinwoodie and Xu, 2008; Denzin and

Lincoln, 2005) utilises mixed methods: quantitative and qualitative methods (Creswell and Creswell, 2013), to build an explicit taxonomy and conceptual framework within a pragmatic paradigm of enquiry (Psillos, 2009; Dewey, 1950). A case based study with the NLNG deploys, inter alia, semi-structured interviews, surveys and archival methods of data collection (Figure 1.1).

Figure 1.1: Paradigm of enquiry, methodology and methods



Source: Adapted from Howell (2013); Guba and Lincoln (2000)

Qualitative data collected in study phase one and study phase three are analysed using template analysis (King and Brooks, 2017; Brooks *et al.,* 2015) to establish generic and explicit SCM strategies that drive financial performance. In study phase two, AHP (Saaty, 1980) measures SCFP drivers and measurement criteria quantitatively to reveal the relative weights of established SCM capabilities in NLNG systems. Three-phased analysis facilitates development of explicit taxonomy, model and conceptual framework of SCFP in NLNG systems, and proposes competitive supply chain initiatives to guide participants in NLNG systems and similar networks to improve their financial results.

1.9 Thesis structure

This thesis consists of the following three main components (Figure 1.2):

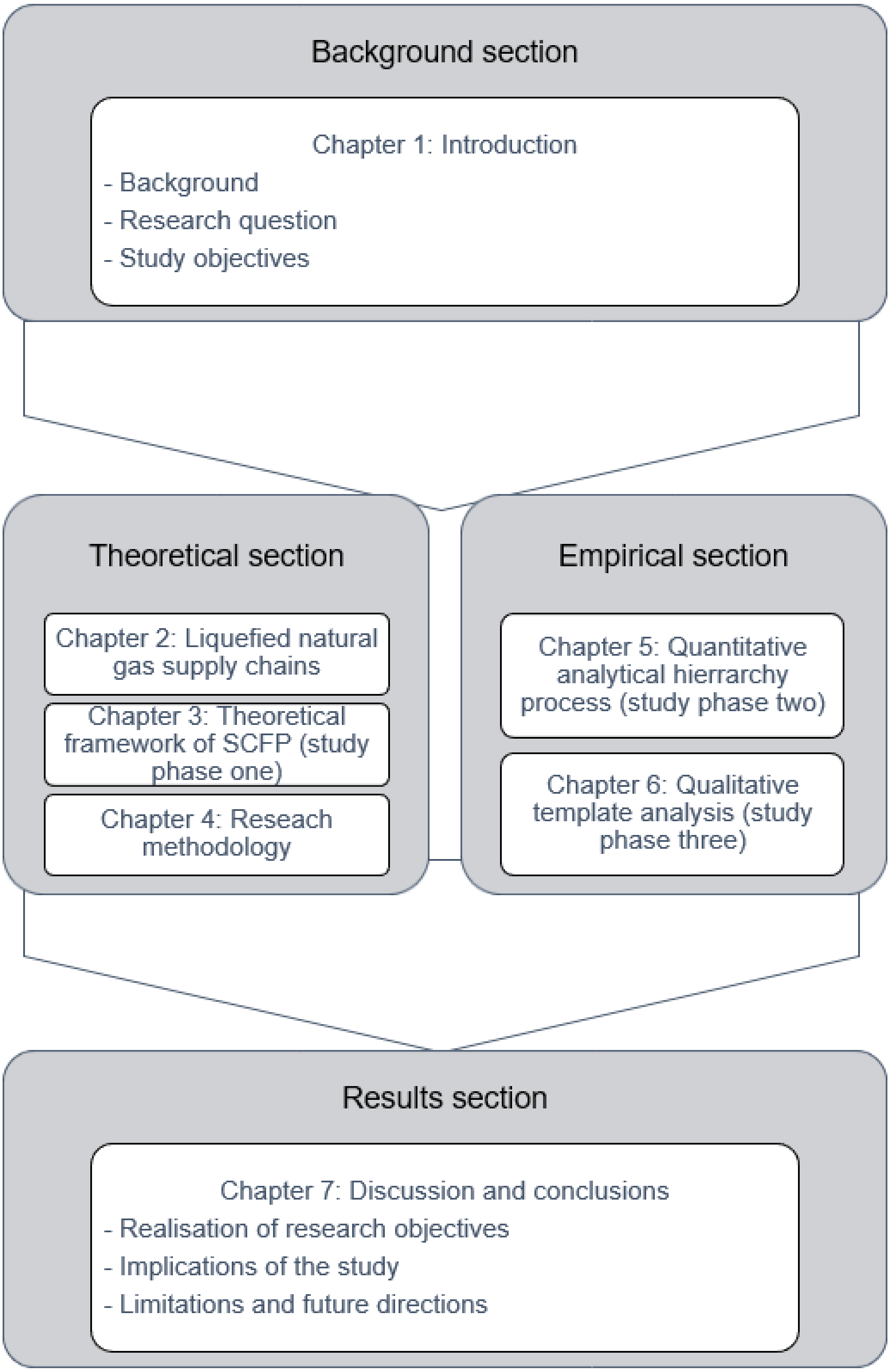
The first section commences with Chapter one, which presents a general background, scope, problem statement, research gap, research question and objectives of the study. In addition, the chapter outlines the methodology employed to address the research question and presents the structure of this thesis.

The second component comprises two sub-sections, the theoretical and empirical components respectively. The theoretical section incorporates chapters two to four. Chapter two critically reviews and analyses existing literature relevant to SCM and LNG networks, to identify the characteristics and analyse the objectives of SCM in LNG distribution systems (Objectives1; 2). Chapter three systematically analyses relevant SCFP literature, to synthesise strategic drivers, capabilities and measures of SCFP and develop a generic conceptual framework of SCFP (Objective 3). Chapter four analyses publications relevant to the case study research methodology that was used for this study and presents methods of data collection, including interviews, surveys and archival studies. Further, template analysis and AHP are discussed as mixed methods of data analysis, which achieve the research objectives and address the research question.

The empirical component of this thesis consists of chapters five and six. Chapter five analyses empirical quantitative AHP and Likert-scale surveys conducted in study phase two, to access the SCFP capabilities in NLNG systems and to propose strategies and policies to improve SCFP in NLNG (Objectives 4; 6). Study phase two prioritised the SCFP drivers and measures established in chapter three in NLNG systems using quantitative survey data collected from supply chain experts at NLNG. To extend study phase two's findings, chapter six analyses empirical qualitative semi-structured interviews conducted with supply chain strategy experts and key decision-makers within NLNG, in study phase three. Case study interviews were analysed using template analysis to develop an explicit taxonomy that defines SCFP in NLNG networks and to propose strategies and policies to improve SCFP in NLNG systems (Objectives 5; 6).

The final section of this thesis discusses how the six research objectives addressed the research question. The influences of this study for research, policy and practice are presented along with limitations and recommendations for further research.

Figure 1.2: Thesis layout



Source: Author

1.10 Summary of chapter one

This chapter introduced developments behind the growing influence of LNG as an energy source. The chapter highlighted the volatility and complexities associated with investment in LNG networks, which pose challenges for LNG operators. The overall focus of this study is to examine LNG SCFP and propose strategies and policies to improve SCFP within the context of NLNG. The research problem that underpins this study was introduced and Nigeria was broached as a case study to investigate the research problem. Six research objectives were proposed to address the prime research question. Further, this chapter presented synopses of the case study methodology and mixed methods of data collection and analysis. The next two chapters review literature relevant to LNG supply chains and theoretical issues underpinning SCFP.

Chapter two: Liquefied natural gas supply chains

2.1 Chapter two overview

This chapter reviews and analyses existing literature relevant to SCM and supply chain networks in LNG systems. Extant SCM literature and publications from NLNG, the LNG sector, and the oil and gas industry were assessed to identify the characteristics of LNG supply chain systems and to analyse the objectives of SCM in LNG distribution systems (Objectives1; 2). These issues are explored in relation to NLNG as a case study. According to GIIGNL (2018)'s report Nigeria is the fourth largest LNG exporting country.

Development in the LNG market, such as demand and supply of natural gas, competition, business strategies, risks, legislations, and financial influences for investors, were examined in this chapter. Further, this chapter identified and analysed LNG supply chain systems from gas exploration in remote fields to consumption by households and industries.

2.2 Developments in supply chain management

SCM is a discipline in the early stages of evolution (Gibson *et al.,* 2005). SCM is a relatively new and evolving discipline, having originated in the manufacturing industries in the early 1980s (Mentzer *et al.,* 2008; Lambert *et al.,* 2008). SCM evolved from inventions such as just in time (JIT) (Vrijhoef and Koskela, 2000) and total quality management (TQM) (Wong and Fung, 1999). The term *supply chain management* first appeared over three decades ago in the practitioner literature in 1982 (Oliver and Webber, 1982). Consultants proposed the term, and since its emergence as an academic discipline in the 1980s, academics have attempted to give SCM theoretical and intellectual meaning. In the 1990s, academics first described SCM from a theoretical point of view to explain the difference from approaches that are more conventional and names such as logistics, to managing material flow and the associated information flow (Cooper *et al*., 1997).

SCM and distribution network design is a subject of increasing interest to academics and practitioners (Sabri and Beamon, 2000; Feldmann and Müller, 2003; Tan *et al.,* 2002). SCM activities have a significant economic impact on countries and societies, for example, it contributes greatly to national gross domestic product (GDP). A small offset in these activities would lead to major environmental impacts from a reduction in the use of fuel, water and other natural resources to decreases in waste and emissions (Grant *et al.,* 2015). This argument gives emphasis to the significance of NLNG networks as a major contributor to Nigeria's GDP. SCM is an evolution and collective innovation, emanating from internal programs aimed at improving overall effectiveness (Saad *et al.*, 2002). The motivation behind SCM is not only restricted to increasing the internal efficiency of organisations, it has been extended to include methods of reducing waste and adding value across the entire network (Harland *et al.*, 1999). SCM has changed emphasis from internal processes to include external relationships and is dependent on the interaction between an organisation and its external environment, having efficient feedback linkages due to supply chain integration and collaboration (Slack *et al.*, 2001).

2.2.1 A supply chain

A supply chain is a network of facilities that performs the procurement of raw material, transformation of raw material into intermediate and finished products and distribution to retailers or directly to consumers (Sabri and Beamon, 2000).

> *"Supply chain links many companies together starting with unprocessed raw materials and ending with the final customer using the finished goods. Supply chain comprises the material and informational interchanges in the logistical process stretching from acquisition of raw materials to delivery of finished products to the end user. All vendors, service providers and customers are links in the supply chains" (CSCMP, 2013: 186).*

A supply chain is a process where three or more entities are involved in the upstream and downstream flows of products, services, finances, and information from a source to a customer (Mentzler *et al.,* 2001).

2.2.2 Supply chain management

SCM is a set of practices designed for managing and coordinating the whole supply chain from raw material suppliers to end customers (Slack *et al.*, 2001), which develop superior synergy through integration of the whole value chain (New and Ramsay, 1997). The Council of Supply Chain Management Professionals (CSCMP) defines SCM as:

> *"SCM encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers" (CSCMP, 2013: 187).*

Christopher (2016) confirms these definitions by describing SCM as the management of upstream and downstream relationships with suppliers and customers to deliver superior value at a minimum cost to the supply chain as a whole. SCM focuses on the management of relationships to achieve a more profitable outcome for all network participants. SCM is the integration of business processes among a network of interdependent suppliers, manufacturers, distribution centres, and retailers to enhance the flow of goods, services, and information from original suppliers to ultimate customers, with the objectives of reducing system-wide costs while maintaining required service quality (Simchi-Levi and Kaminsky, 2000).

2.2.3 Supply chain relationships

In a supply chain relationship, facilities that usually belong to different companies, consisting of production plants, distribution centres and warehouses are integrated as a value stream in such a way that a change in any one facility affects the performance of others (Sabri and Beamon, 2000). Deduced from previous supply chain studies, Mentzler *et al.* (2001: 4) identify three levels of supply chain structure, consisting of a direct, an extended, and an ultimate supply chain (Figures 2.1-2.3).

Figure 2.1: Direct supply chain

Source: Adapted from Mentzer *et al.* (2001: 5)

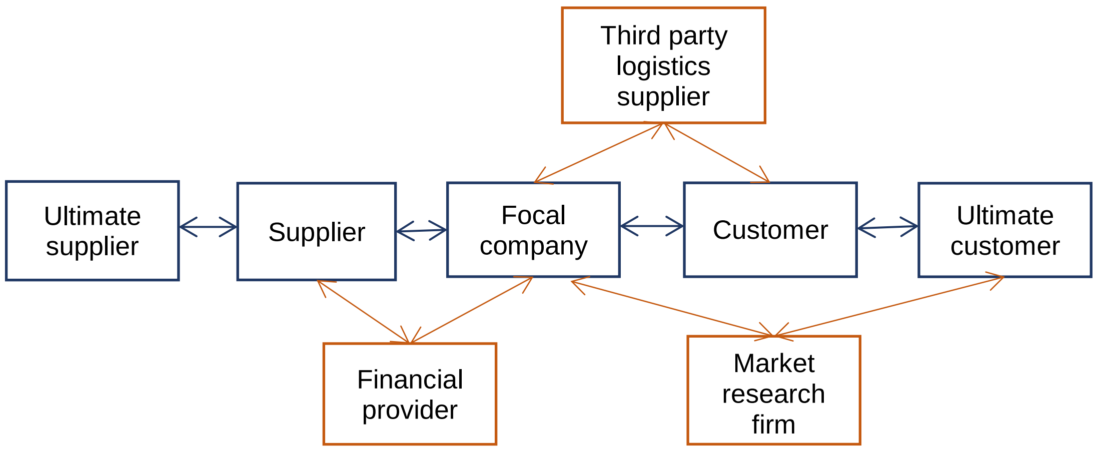
A direct supply chain consists of a firm, a supplier, and a customer involved in the upstream and/or downstream movements of products, services, finances and information.

Figure 2.2: Extended supply chain

Source: Adapted from Mentzer *et al.* (2001: 5)

An extended supply chain includes suppliers of the immediate supplier and customers of the immediate customer, all involved in the upstream and/or downstream flows of products, services, finances and information.

Figure 2.3: Ultimate supply chain



Source: Adapted from Mentzer *et al.* (2001: 5)

An ultimate supply chain comprises all the participants involved in all the upstream and downstream flows of products, services, finances and information from the ultimate supplier to the ultimate customer. As presented in Figure 2.7, NLNG supply chain systems is a typical ultimate supply chain structure.

Chopra and Meindl (2007) state that a supply chain consists of all steps and functions involved, directly or indirectly, in fulfilling a customer request. A supply chain does not only include the manufacturer and suppliers, but also transporters, warehouses, third party logistics providers (3PLs), retailers, and customers. SCM functions include, but are not limited to, new product development, marketing, operations, distribution, finance, and customer service. SCM is associated with the effective management of the interfaces between all the network participants (Von Hipple, 1986), and the integration of upstream and downstream processes (Christopher and Juttner, 2000). There is significant emphasis on co-ordination and integration, which is strongly linked to the development of effective and longer-term relationships between customers and suppliers (Kosela, 1999). This style of relationships is perceived as a means to utilise resources better through the whole nwtwork (Dubois and Gadde, 2000). Furthermore, an integrated supply chain can also lead to greater transparency in transactions, increased trust and commitment (Ali *et al.*, 1997). It is also an important element in organisation, processes and product innovation (Edum-Fotwe *et al.*, 2001). Supply chain relationships has resulted in an increasing adoption of joint ventures (JV) and alliances to realise significant common benefits involving sharing resources, information, and learning and other key assets (Akintoye *et al.*, 2000).

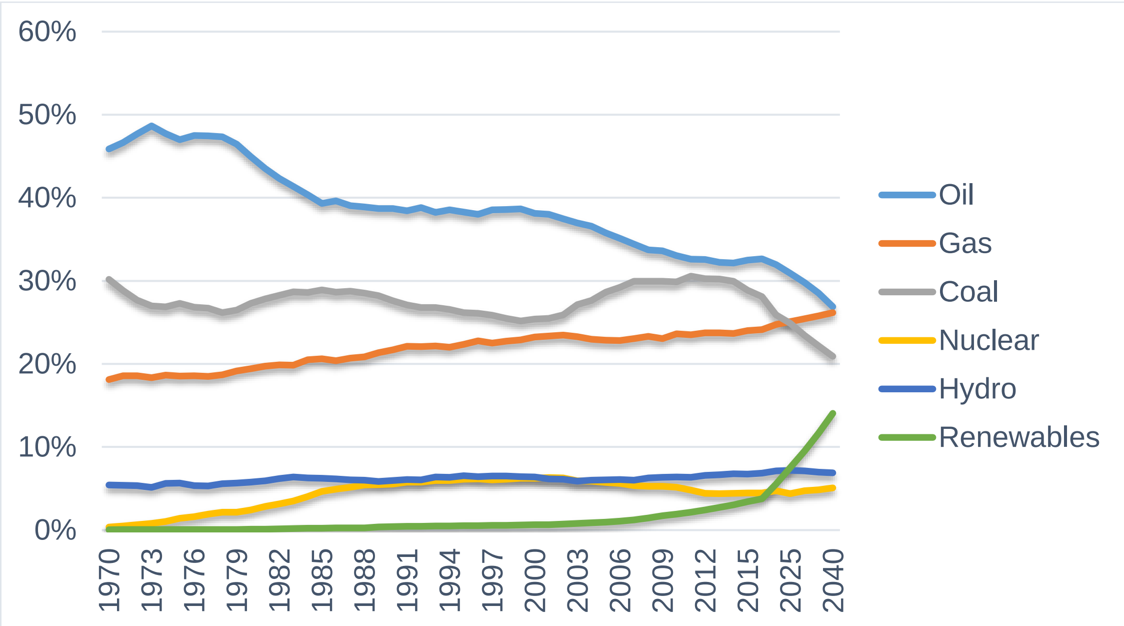
SCM is a complex and dynamic practice, its successful application needs a thorough understanding of the concept (Whipple and Frankel, 2000). SCM entails new organisational arrangement and culture, which calls for substantial commitment, resources and time to develop (Neely, 1998). It is imperative to recognise that SCM is complex and has proved to be difficult to implement. SCM is a multi-factor process, dependent on close and long-term relationships within and between organisations (Saad *et al.*, 2002). SCM success is linked to the challenges and difficulties in developing of a new culture based on shared learning, greater transparency and trust. With a more reliance on suppliers, increasing outsourcing and aggressive competition, the major challenge for SCM is to maintain and continuously improve the management and integration of all interactions and interfaces to improve the overall network performance, including SCFP. It is essential to build SCM framework based on continuous improvement to enhance performance.

2.3 The global energy industry

The ancient Greeks, Romans, and Chinese made limited use of natural gas but it only became a significant source of energy in the 20th century. Thanks to technological developments in long-distance pipeline transportation, natural gas became widely distributed, allowing it to be a substitute for coal. These technological advances contributed to the stable growth of natural gas demand throughout the 20th century, with the pace of growth accelerating in the later decades of the century and into the 21st century (Tusiani and Shearer, 2016). The need for lower-carbon fuel has led to increasing demand of gas, the least carbon-intensive fossil fuel, as an energy source. Industry leaders are convinced by the case for gas in the unfolding energy transition. A survey conducted in 2018 showed that 86% of global sector leaders agree that gas will play an increasingly important role in the global energy mix over the next decade, up from 77% in 2017 (DNV GL, 2018). British Petroleum (BP) estimated that world GDP will increase by more than 100% by 2040, with growth averaging 3.4% p.a. driven by increasing prosperity in fast-growing emerging economies, as more than 2.5B people will be lifted from low incomes. This increasing prosperity will drive an increase in global energy demand, although the magnitude of this growth will be offset substantially by rapid developments in energy efficiency, yet, energy demand will increase by around 30% during this period (BP, 2018b; BP, 2017).

Clarksons (2016) asserted that in the last three decades, natural gas has increased its share from 19% in 1975 to 24% of global energy production in 2015, a level it has maintained since 2007. Between 2000 and 2015, natural gas consumption grew at a compound average rate of 2.5% per year, double the growth of oil consumption. Natural gas demand is expected to increase significantly in the long term, with the International Energy Agency (IEA) (2012) projecting between 2013 and 2040 an average annual growth rate of 1.4%, compared to 0.4% for oil over the same period (Figure 2.4). Consequently, the natural gas share of total energy consumption is expected to increase to 25% by 2025, which will make it the world's second largest primary energy source after oil (Alberto and Sauer, 2006). The stage is set for gas to become the world's largest energy source in the mid-2030s (DNV GL, 2018). These should be exciting developments for the Nigerian gas industry and the economy at large. As at the end of 2017 Nigeria has total proved natural gas reserves of 5.2T m^3, which is 2.7% of world proved reserves, making 9th in the world and 1st in Africa in terms of natural gas deposit (BP, 2018a; BP, 2016; EIA, 2016).

Figure 2.4: Share of primary energy



Source: BP (2018b: 68)

Nearly two-thirds, 64%, of the industry's senior professionals expected increase or sustain spending on gas projects in 2018 (DNV GL, 2018). The rapid growth of natural gas is strongly supported by an increase in demand and the continuing expansion of LNG increasing the availability of gas globally (BP, 2018b) and the energy transition to natural gas is the primary driver of investment in LNG projects

(DNV GL, 2018). Although pipelines are the major delivery method in the global natural gas trade, and are highly cost efficient over short distances, it is not technically feasible and economically viable when the supplier and customers are geographically dispersed. In such cases, natural gas is transported in the form of LNG, utilising special ocean-going vessels over long distances (Mutlu *et al.* 2016; Raju *et al.,* 2016). Whilst pipeline trade remains the dominant method of transporting natural gas, LNG has become more important in the global natural gas trade in recent years (Clarksons 2017: 10). LNG facilitates a third of natural gas trade (Raju et al, 2016) (Figure 2.5).

2.4 Liquefied natural gas

During the second half of the 20th century, gas traded in the form of LNG became an essential component of international trade, particularly in Asia (Tusiani and Shearer, 2016:9). LNG is natural gas, primarily composed of methane, which has been converted into liquid for ease of storage and transport (GIIGNL, 2014b). LNG is natural gas that through a refrigeration process has been reduced to a liquid state, which represents approximately 1/600th of its gaseous size (GIIGNL, 2014a; Scheig, 2009). The conversion of natural gas to its liquefied form allows for the transport of larger volumes. Depending on its composition, natural gas becomes liquid at approximately -162°C or -259°F atmospheric pressure. The importer through regasification process warms the LNG and converts it back into its gaseous form for distribution to industrial and residential consumers (GIIGNL, 2014a).

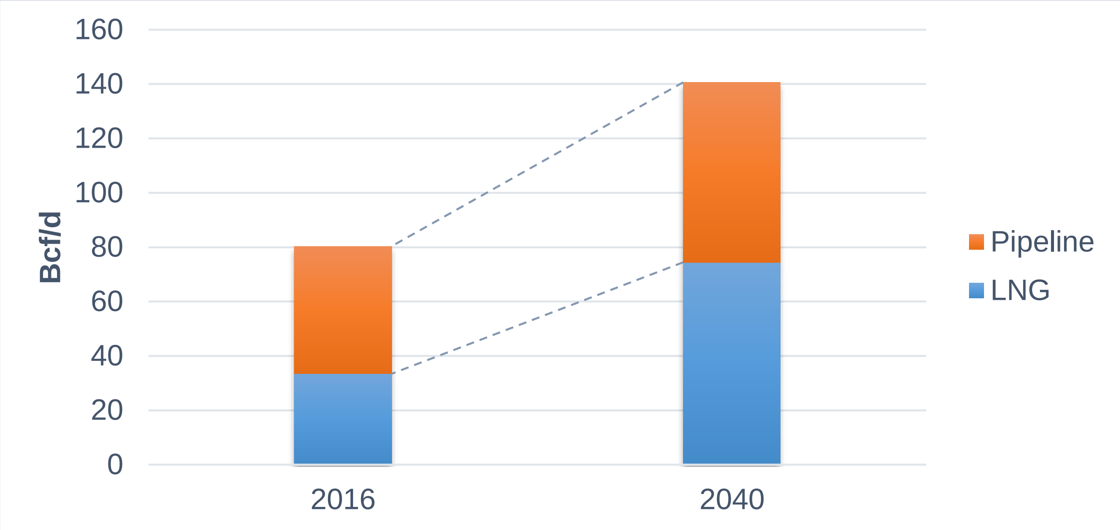
Özelkan *et al*. (2008) asserted that owing to the physical nature of natural gas, the most economical means of transportation over long distances is by liquefaction of the gas and shipment on specially designed LNG tankers. Scheig

(2009) corroborated this assertion, stating that the liquefaction of natural gas allows it to be economically shipped from areas of the globe where natural gas is abundant and inexpensive to produce, to other areas in deficit. Liquefying natural gas and shipping it via ocean-going vessels is cheaper than pumping through off-shore pipelines if the market is more than 1100 km or 700 miles, and 3500 km or about 2200 miles for on-shore pipelines (Nikhalat-Jahromi *et al.*, 2017a).

Whilst pipeline remains the primary method of transporting natural gas, LNG is growing rapidly in global natural gas trade in recent years. Several countries have sought to import natural gas via LNG rather than pipeline, whilst the development and increased usage of floating storage regasification unit (FRSU) technology has also meant that some countries were able to import LNG relatively more quickly and potentially at a lower cost than by constructing land-based terminals. LNG transport represented 32% of world natural gas trade in 2016, compared to 26% in 2005 (Clarksons, 2017).

It is estimated that LNG will grow seven times faster than pipeline gas trade and will account for around 50% of all globally traded gas by 2035 from 32% in 2015 (BP, 2017). Global LNG supplies will more than double by 2040, with around 40% of that increase occurring over the next five years. LNG volumes will overtake inter-regional pipeline shipments by the early 2020s (BP, 2018b). The demand for LNG grows faster than demand for pipeline gas (Kumar *et al.,* 2011). Shipping NG in the form of LNG offers gas suppliers the ability to reach distant markets (Mutlu *et al.*, 2016). Another advantage of LNG-based trade over pipeline gas is LNG cargoes can be redirected to different parts of the world in response to regional fluctuations in demand and supply. As a result, gas markets are likely to become more integrated across the globe (BP, 2017). The market for natural gas has progressively become global, and technological advances in the maritime industry have made ships essential for long distance transportation of NG (Andersson, 2016). LNG exports are expected to supply around two-thirds of the increase in natural gas exports, with rising pipeline imports from Russia providing the remainder (BP, 2017). Consequently, the need to develop resilient and effective LNG supply chains are paramount, as expansion of LNG helps support gas consumption (Figure 2.5).

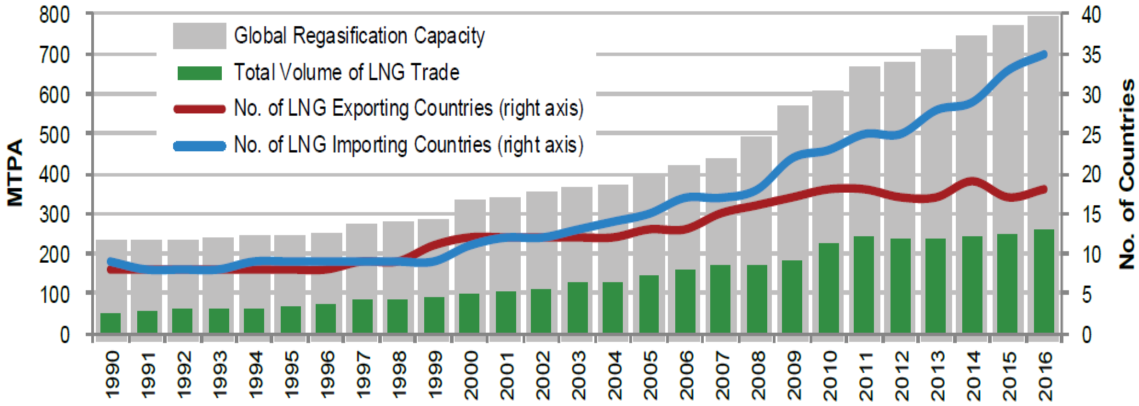
Figure 2.5: Natural gas trade



Source: BP (2018b: 80)

The significance of the LNG in global energy trade has grown over the past decades (Nikhalat-Jahromi *et al.*, 2017a), due to growth in energy demand and the transition to a low carbon economy (Nikhalat-Jahromi *et al.*, 2016). With global LNG tonnage increasing by 7.4% in 2016. However, as LNG supply has grown and gas prices have fallen, many countries have sought to import natural gas via LNG rather than via pipeline. The development and increased usage of FSRU technology has also meant that some countries have been able to begin importing LNG relatively more quickly and potentially at a lower cost than by constructing land-based terminals. LNG transport represented 32% of world natural gas trade in 2016, compared to 26% in 2005. Global LNG exports further grew by 9.9% in 2017, reaching 289.8 Mt, which was the highest annual growth rate since 2010 (GIIGNL, 2018). LNG production capacity is growing at a fast pace and the number of LNG exporting countries has risen to nineteen (GIIGNL, 2017) from only five in 1980 (IGU, 2017) (Figure 2.6). The LNG market is expected to grow even faster in the next two decades (BP, 2017) (Figure 2.5).

Figure 2.6: Liquefied natural gas trade volumes



Source: IGU (2017: 7)

2.5 Nigeria liquefied natural gas

The timing and importance of this study and other similar study to academics, industry and policy makers especially those associated with the NLNG cannot be overemphasised. The NLNG was incorporated on May 17, 1989 (NLNG, 2018a; 2017), with a mandate of utilisation and monetization of Nigeria's natural gas resources (Nwaoha and Wood, 2014) which is otherwise flared (Adekomaya *et al.,* 2016). There is a significant reduction in the amounts of black carbon since the inception of NLNG when compared to four preceding decades, the probable explanations is the utilisation gas as LNG (Giwa *et al.,* 2014). However, till date there is only one active LNG facility in Nigeria, which is the NLNG at Bonnie Island, with the other two LNG development projects that were conceived in 2005 to boost Nigeria's gas supply, namely Brass LNG and Olokola LNG (OKLNG) facing serious challenges. The long delayed OKLNG project has been cancelled (Clarksons, 2016) despite initial investment of USD 547M, and the shareholders of Brass LNG are yet to sign the final investment decision (FID) (Thisday, 2017).

The NLNG, a JV between the NNPC, Shell BP, Total and Eni, with 49, 25.6, 15 and 10.4 percent holdings respectively, seems to be facing some difficulties. There was a change of plans, from developing two LNG processing trains of 8.4 Mtpa each (IGU, 2017: 70), the project is currently considering only one train, NLNG train 7 with the capacity of 8.5 Mtpa. The NLNG 7 project is still in the front-end engineering design (FEED) stage and has seen its start-up date pushed back further to 2020 from an original start-up date of 2012 (Clarksons, 2017; Clarkson, 2016). The Managing Director (MD) of NNPC asserted that a final investment decision (FID) for NLNG Train 7 will be reached before the end of 2018. However, this is not the first time NNPC is making such a declaration (The Guardian, 2018).

For a decade, Nigeria has averaged 4th position in terms of LNG export, however, it has failed to grow over this period. Nigeria in the past few of years has not even maintained its position, thereby surrendering its competitive edge as a major LNG exporter (Clarksons, 2016). Qatar, a major LNG exporter, the US, a new exporter, and Australia, a relatively new and fastest growing LNG producer, are expected to dominate the LNG market for the next 20 years (GIIGNL, 2017: Clarksons, 2016: IGU, 2017). Nigeria has more proven reserves than some of its competitors in the LNG industry (BP; 2018a; BP, 2016), however, in 2017 Nigeria exported only 20.28 Mt, the second lowest export volume compared to the other big 5 LNG exporting countries (GIIGNL, 2018). Nigerian LNG exports fell for the first time since 2013 by 9% in 2016, which poses a challenge to NLNG to maintain its competitiveness as a major player in the LNG industry (Clarksons, 2017). These challenges have serious financial influences for investors, supply chain partners, and Nigeria as a country due to the contribution of oil and gas revenue as a major source foreign exchange.

The declining LNG exports volume from Nigeria is associated with lack of investment in new LNG projects, expansion of existing project, and pressure from continued disruptions in the Niger Delta region (Clarksons, 2017). A deteriorating security situation in Niger Delta region led to a brief force majeure period at the NLNG facility in December 2015 (Clarksons, 2016). The difficulties NLNG is experiencing could be attributed to the SCFP capabilities in NLNG systems which this study assessed (Objectives 4; 5) later in this chapter and in chapter 7.

Global LNG supply is expected to grow rapidly, steered by growth in the US with 19bcf/d and Australia with 3 bcf/d. Asia remains the leading destination for LNG. China, India and other Asian countries all increase their demand for LNG, helping gas to grow faster than oil or coal in these economies. Europe also makes increasing recourse to LNG to relieve the growing gap caused by declines in its domestic production (BP, 2017). Group Chief Executive of BP asserted that:

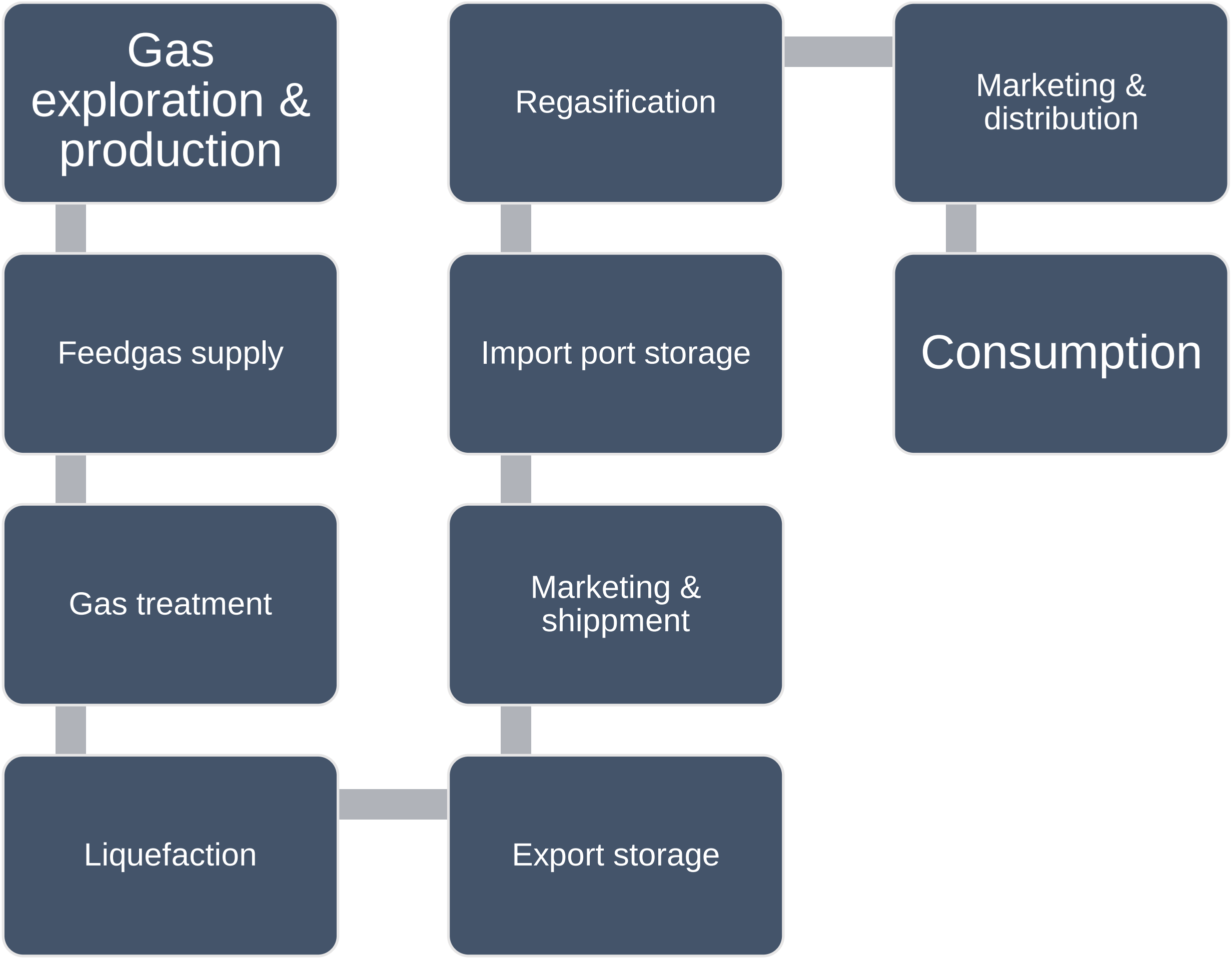
> *"… strong expansion of global LNG supplies helped to improve the accessibility of gas around the globe, with clear signs that the major regional gas markets are becoming increasingly integrated. This greater accessibility and integration should help to underpin the long-term use of natural gas" (BP, 2018: 1).*

LNG exports is indeed the major contributing factor to the growing integration of global natural gas markets (Barnes and Bosworth, 2015).

2.6 Nigeria liquefied natural gas supply chains

The LNG supply chains are the stages used to produce and ultimately deliver LNG to consumers. These components consist of three value streams, namely upstream, midstream and downstream. Upstream consist of natural gas extraction and gas feedstock (feedgas) supply. Midstream includes gas treatment, liquefaction, storage, and transportation. Downstream consist of regasification and distribution (GIIGNL, 2014b) (Figure 2.7). NLNG like any other LNG producer has mainly control of the supply chain midstream, including gas treatment, liquefaction, storage and shipping, which is also the scope of this study. Since 1964, LNG production, export, import and distribution has followed a similar process sequence (Pirrong, 2017; GIIGNL, 2014b). The LNG supply chain begins with the natural gas being extracted and sent through gas transmission systems (GTS or pipelines) to a nearby liquefaction plant. The gas is treated to remove other materials and particles, then processed by production train through a refrigeration process into liquid state and stored in tanks (Table 2.1). Further, the LNG is pumped to ships for transportation to its destination terminals. There, it is again stored until it is regasified and finally sent through pipelines to the end users (Andersson, 2016) (Figure 2.7). The LNG supply chain consists of three distinct parts of liquefaction, shipping and regasification (Sousa and Flippen, 2005). The LNG business can be described as a value chain containing four elements, comprising of gas exploration and production, liquefaction, shipping and regasification (Scheig, 2009, 15).

Figure 2.7: Liquefied natural gas supply chain

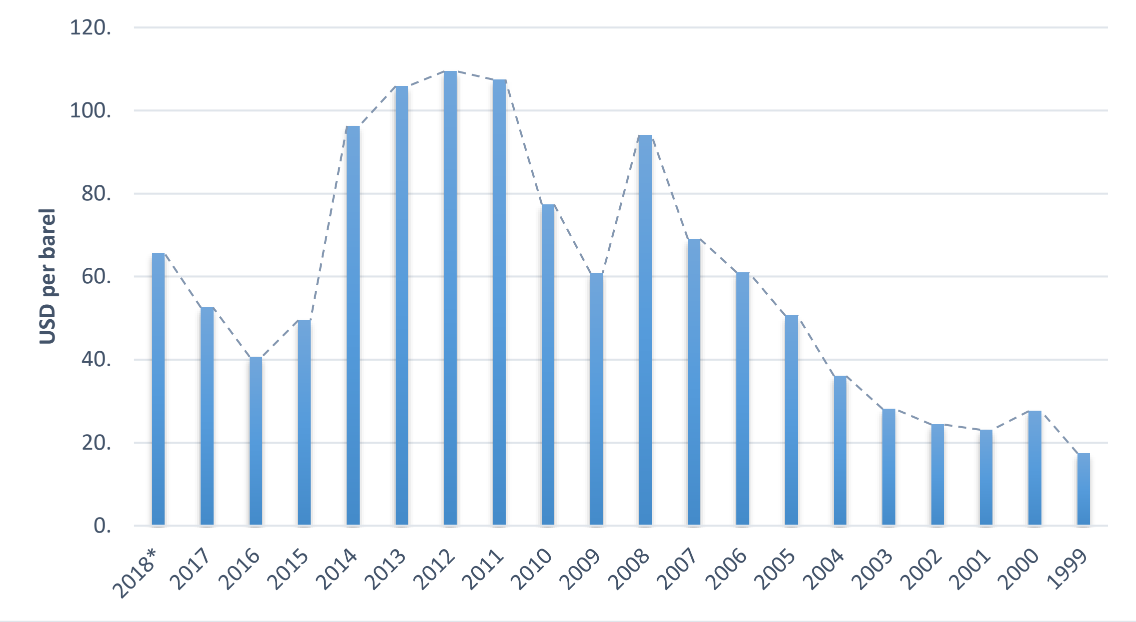


Source: Author

SCM strategies are necessary to optimise financial performance. Operational constraints include feedgas supply, production capacity, tank levels, port terminals and vessel capacities, which are major midstream features of LNG networks (Table 2.1). Financial performance can be improved by managing variability in demand, transit times for vessels, as well as general delays and disruptions along the network linkages.

The LNG SCM has become more important due to the increased gas demand and the need for imported LNG (Andersson 2016; Özelkan *et al.,* 2008). LNG currently represents the most exciting aspect of the international gas landscape (OPEC, 2016). However, it is important to note that the economic feasibility of the LNG supply chain is driven by factors, including minimising the cost of LNG (OPEC, 2016; Berle *et al.*, 2011) and maximising the volume send-out into the market while minimising the inventory of storage gas (Özelkan *et al.,* 2008). The growth in the number of participants in the industry has led to a huge increase in supply, supply chains have become more competitive and the price of LNG has fallen. In countries like the United Kingdom (UK) and the US where the market is liberalised, prices are determined by competition among different suppliers (Energy Charter Secretariat, 2007). Furthermore, in the entire South and East Asian region, Japan customs-cleared crude oil price (JCC) is used for LNG, which pegs LNG price to oil price (Energy Charter Secretariat, 2008). Hence, the price of oil became the reference point for the competitive pricing of LNG in that region (Energy Charter Secretariat, 2009). This further places LNG producers in an unfavourable position since the recent global downturn in the price of petroleum products from 2014 to 2018 (Figure 2.8).

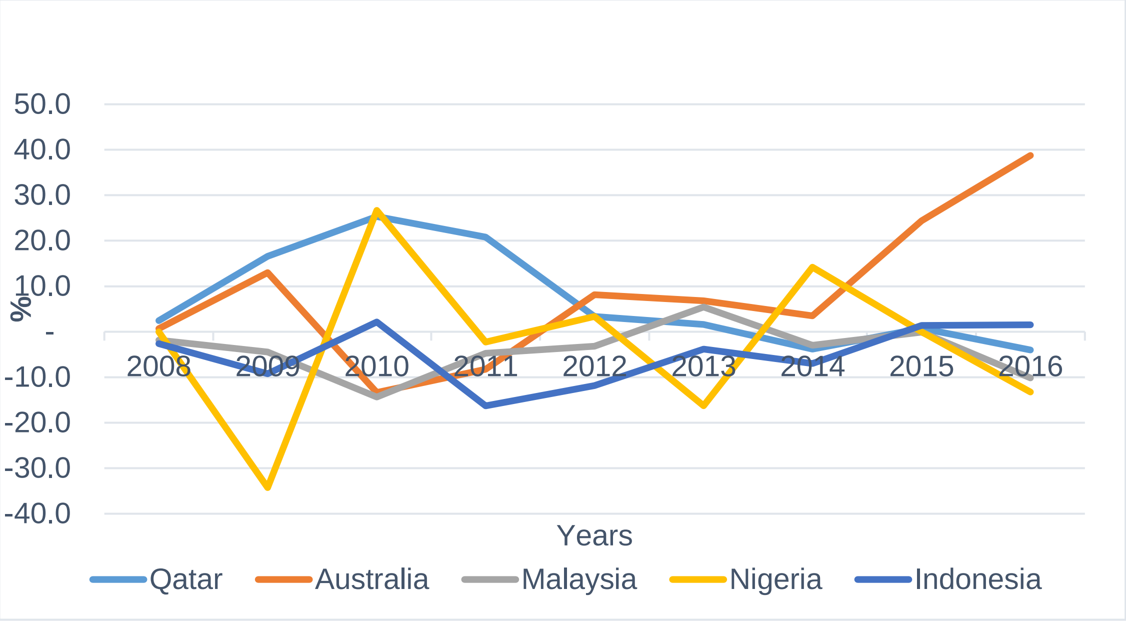
Figure 2.8: Twenty years average annual OPEC crude oil price



Source: Adapted from Statista (2018a)

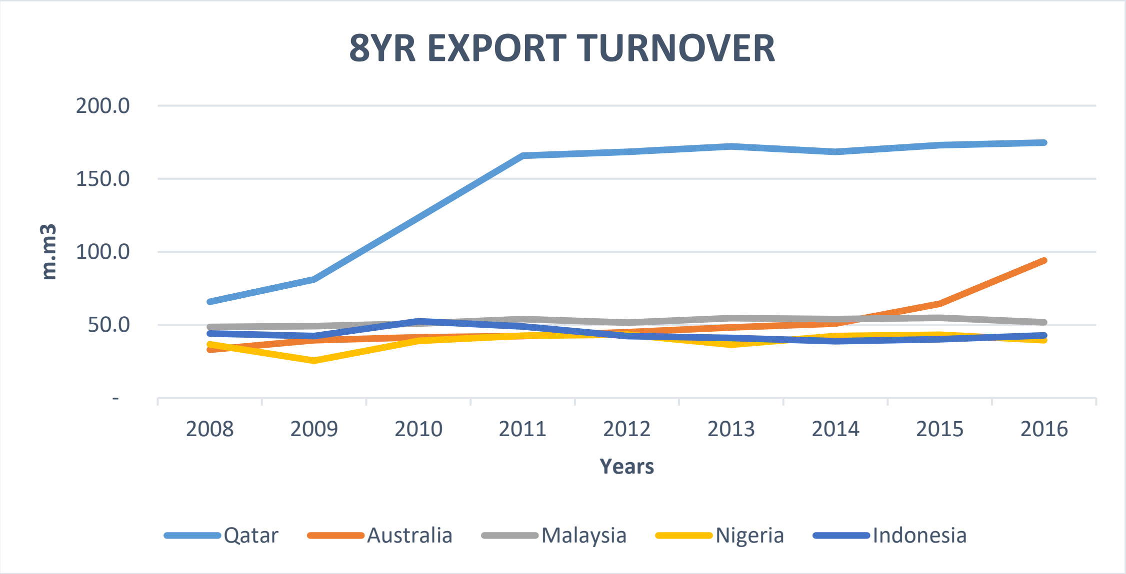
The natural gas price has fallen from USD 4.8 in 2014 to as low as USD 1.7 in 2016 (Nasdaq, 2017), in the same period LNG price plunged from USD 15 to USD 5 / k ft^3 (EIA, 2017). Consequently, the NLNG revenue dropped from USD 10.79B in 2014 to USD 6.84B in 2015 and further dropped to USD 4.72B in 2016 (Ship and Ports, 2017). These developments affected all key industry participants, especially LNG exporters. LNG producers strive to minimise capital expenditure (CAPEX) and operating expenditure (OPEX) requirements by means of tightly engineered strategic supply chains. The importers on the other hand want reliable delivery and value for money. The turbulence faced by NLNG networks was steeper and more volatile than that of its competitors (Figures 2.9; 2.10), and this study is looking inward into NLNG supply chain capabilities to identify strategies to improve their systems by cutting costs, improving productivity and customer base, as well as achieving sustainability in the long-run (objectives 4-6). In addition, this work revealed that oil and gas companies face challenges in the context of increasing demands to take on public responsibilities while remaining profitable. For example, Shell has invested tens of millions into CSR activities in Nigeria annually (Pendleton *et al.* 2004); however, in January 2013 Shell was held liable in The Hague for oil pollution in the Niger Delta region of Nigeria (Hennchen, 2015).

Figure 2.9: Market share of major liquefied natural gas exporters



Source: Adapted from Clarksons (2017: 15)

Figure 2.8: Export turnover by major liquefied natural gas exporters



Source: Adapted from Clarksons (2017: 15)

2.7 Value chains within NLNG supply chains

To address the research question and achieve the study objectives by analysing supply chain strategies to minimise cost and maximise output, and ultimately to improve SCFP in NLNG (objective 2; 4; 5; 6), this work reviewed the activities involved in the midstream of LNG supply chains.

Table 2.1: Objectives of liquefied natural gas supply chains

Components	Description	Characteristics	Goals/challenges
Feedgas	Natural gas from fields	Transported in pipelines	Steady usage
Liquefaction plant	Cleans and cools gas to liquid state at 161 °C	High investment and operational cost	Maximise utilisation without interruption
Export storage	Storage of LNG before loading	High investment cost	Minimise required capacity
Loading	Moving LNG to vessel	Specialised infrastructure	Safe loading, maximize throughput capacity
Port/vessel interface	Scheduling and coordinating of vessels	Vessels serve as storage in system	Minimize time for berthing
Shipping network	Owned, chartered (and spot) vessels	Decisions on utilisation of owned and chartered fleet	Maximize profits, recourse action for deviation management
Port/vessel interface	Scheduling and coordination of vessels	Planned delivery of gas	Minimize time for berthing
Unloading	Moving LNG from vessel	Specialized infrastructure	Safe unloading, maximize throughput capacity
Storage	Storage of LNG	High investment cost	Minimize capacity requirement
Regasification	Evaporating LNG to natural gas	Moderate investment	Meet gas demand without interruption
Gas consumption/gas storage	Use of gas, gas to transportation system, gas to storage	Variability in demand with stochastic Uncertainty	Meet gas need

Source: Berle *et al*. (2011: 701)

Just like other major LNG exporters, the NLNG is a focal corporation within the NLNG systems, situated in the midstream of the value chains (Table 2.1), which is made of the infrastructure that delivers natural gas from its stranded deposits in remote areas of the world over thousands of miles to major markets. The NLNG value chain contains feedgas supply, liquefaction of gas into LNG, LNG storage, LNG export terminal operations and LNG shipment (NLNG, 2016; Jokinen 2015) (Figures 2.1).

2.7.1 Feedgas supply

This involves transfer of gas in its natural form from extraction and production fields on and offshore, upstream, via GTS to an LNG processing facility (Berle *et al*., 2013; Berle *et al*., 2011) (Table 2.1). Feedgas as the source of input in NLNG supply chain has faced serious threats over the years due socio-political challenges in Niger Delta region of Nigeria where NLNG is located. In NLNG 2015 group annual report and financial statements, the then MD identified that *"the security of our gas supply systems remains a critical challenge, with number of threats to gas supply reliability, including 4 major gas transmission system's leaks due to 3rd party sabotages. These incidents resulted in force majeure declarations by two of our gas suppliers, and reduced feedgas availability"* (NLNG, 2016). This poses a major threat to SCFP in NLNG systems due to cost impacts of such stoppages; including GTS repairs, liquefaction train shutdown and restart, damages and claims. Assets such as GTS, trains, tanks, terminals and vessels are also underutilised during such period. Revenue is completely lost for the entire period of shut down because NLNG could not produce the LNG to sell to its customers downstream in the supply chain.

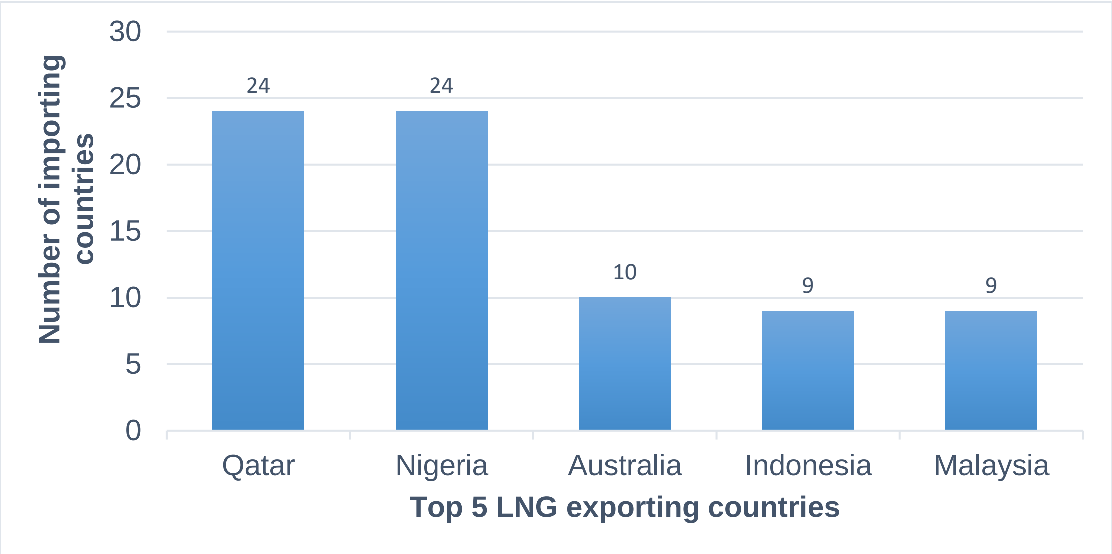
The liquefaction plant should ideally run at 100% capacity to maximise financial performance. Customer demand for LNG should be satisfied by providing stable deliveries to maximise profit (Berle *et al.,* 2013). Performance optimisation in NLNG systems can be achieved where there is 100% utilisation of LNG trains without any unplanned downtime, and where there is no excess supply of feedgas beyond plant processing capacity. The performance of the feedgas is measured in either economic loss, time or volume unavailability. Due to high capital-intensive nature of the liquefaction plant, a goal of operation is to minimise down time and the goal of the transportation planning system is never to require the LNG liquefaction plant to reduce production to improve financial performance in LNG supply chains (Berle *et al.,* 2013).

2.7.2 Liquefaction

The liquefaction component of the LNG supply chain is the most capital intensive, with projects often costing several billion dollars. Key risks facing liquefaction projects include completion risk, supply risk, market risk, pricing risk and political risk. Liquefaction facilities are often located in some of the world's most remote locations and coordinating their construction can be a massive challenge, especially in the greenfield development (Sousa and Flippen, 2005). Werner *et al.* (2014) analysed that liquefaction terminals transform natural gas into LNG at a fixed unit cost, at a rate between the terminal's minimum production rate and maximum capacity. The produced volumes should match contractual purchases from the liquefaction terminal.

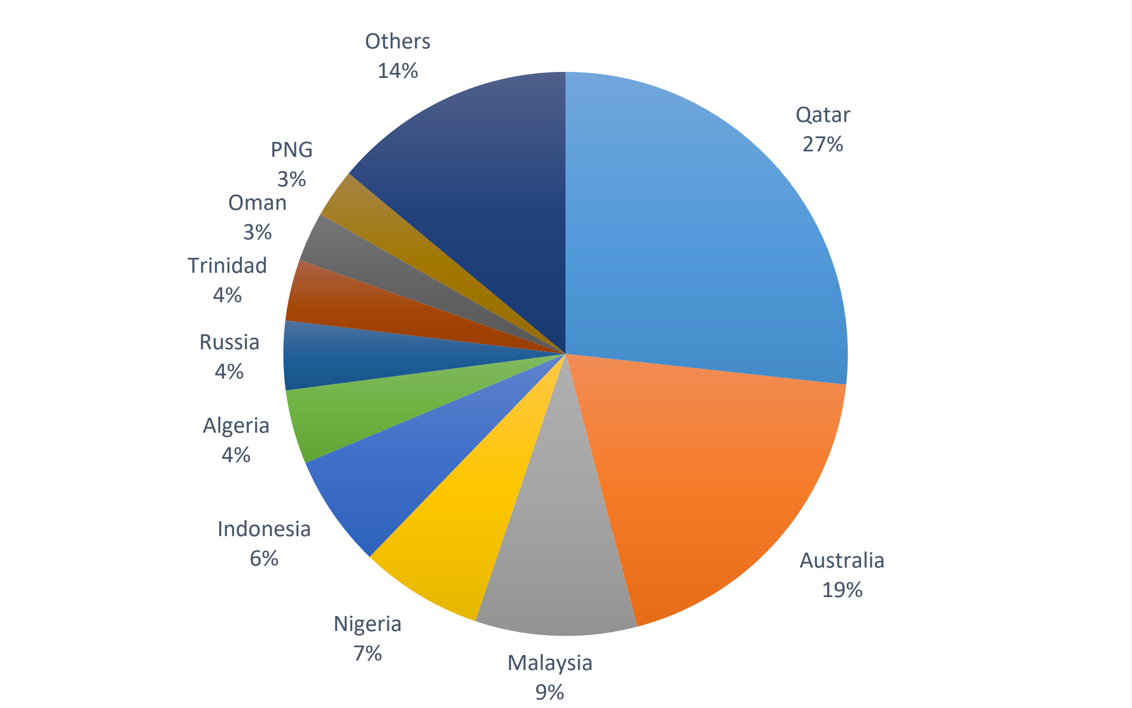
In total, 24 countries including 7 in Asia, 8 in Europe, 5 in the Americas and 4 in the Middle East, imported LNG from Nigeria in 2017. NLNG enjoys a joint first with Qatar in terms of market spread. Australia and Malaysia who are number 2 and 3 exporters of LNG did not export LNG to Europe and America during this period. Indonesia only exported 0.19 Mt to Mexico in America and did not export to any European country in 2017 (Figure 2.11). This advantage is largely due to the high number the number of vessels that NLNG has relative to its liquefaction capacity (Figures 2.13; 2.14) and positional advantage of being the only major exporter on the Atlantic basin. However, NLNG could not maximise this advantage, with only 6 liquefaction trains on stream (Figure 2.13) with a maximum liquefaction capacity of 22.2 Mtpa against the top 3 with 77, 65.3 and 30.5 respectively (Figure 2.14).

Figure 2.9: Customer diversification as at 2017



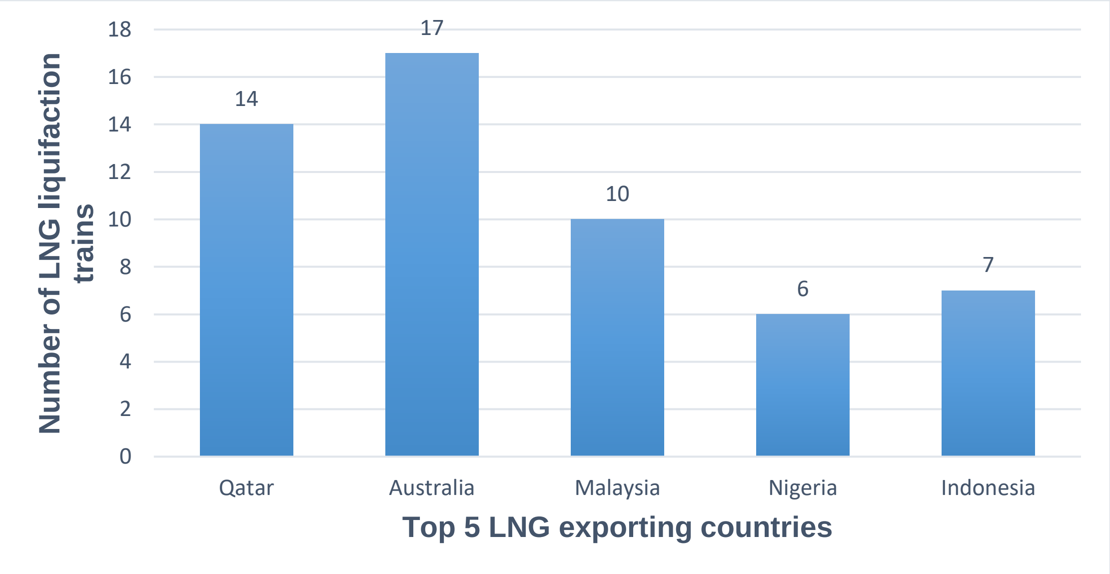
Source: GIIGNL (2018)

Figure 2.102: Market share of major LNG exporting countries in 2017



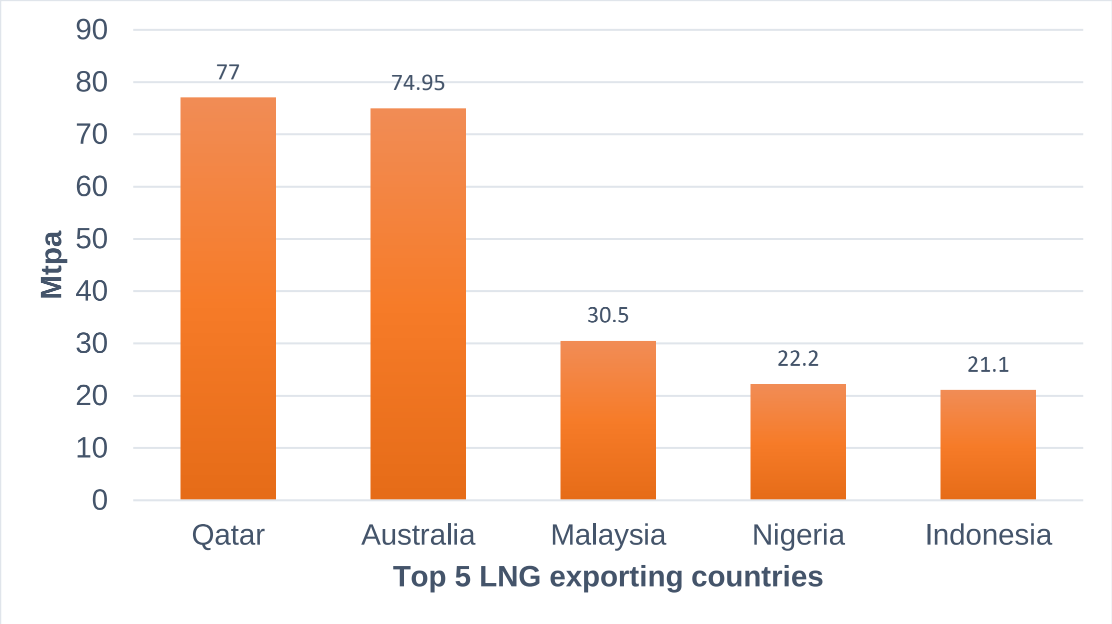
Source: GIIGNL (2018)

Figure 2.13: Number of liquefaction trains as at 2017



Source: GIIGNL (2018: 24; 25)

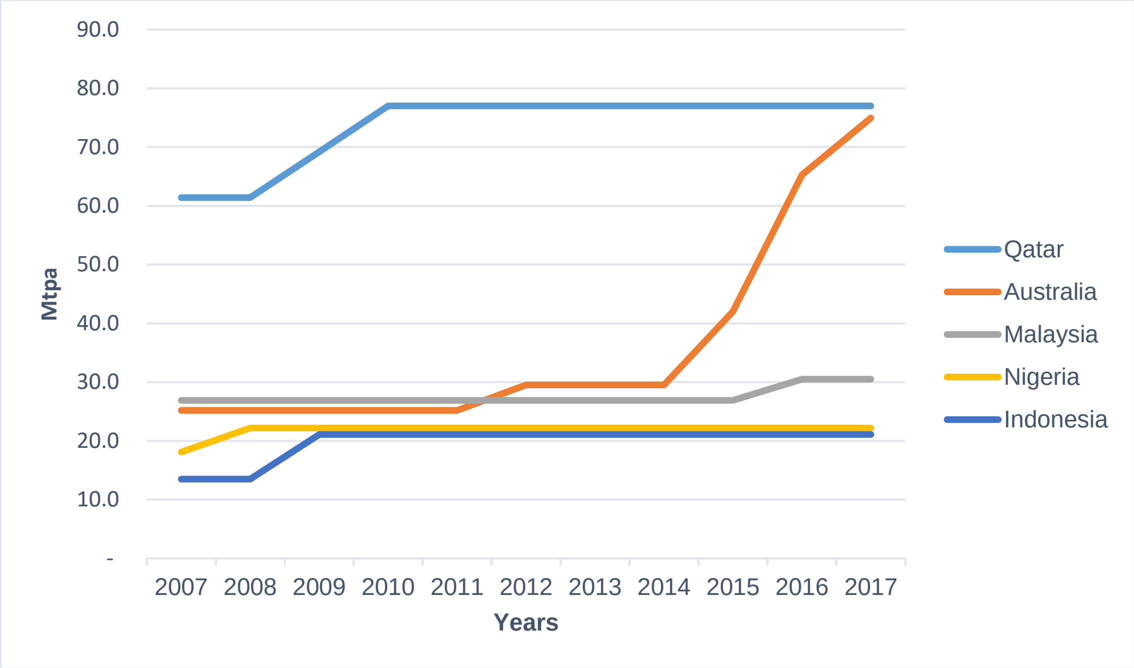
Figure 2.14: Liquefaction capacity as at 2017



Source: Adapted from GIIGNL (2018)

There has been no further investment since the launch of NLNG T6 with the capacity 4.1 Mtpa in 2008, which is the second lowest investment in liquefaction capacity after Malaysia who invested in only 3.6 Mtpa in the 10-year period. Australia was not a major player 10 years ago, but is now 2nd largest LNG exporter largely due to investment of 49.8 Mtpa during same period, which is over 1,200% of NLNG investment in liquefaction capacity (Figure 2.15). The lack of investment in liquefaction capacity growth (Figures 2.13-2.15) in NLNG can be associated with challenges facing its supply chain capabilities such as feedgas; integration with upstream and downstream partners; as well as IT and automation. These supply chain challenges could pose significant challenges for LNG volumes, which have a direct relationship with revenue and financial performance.

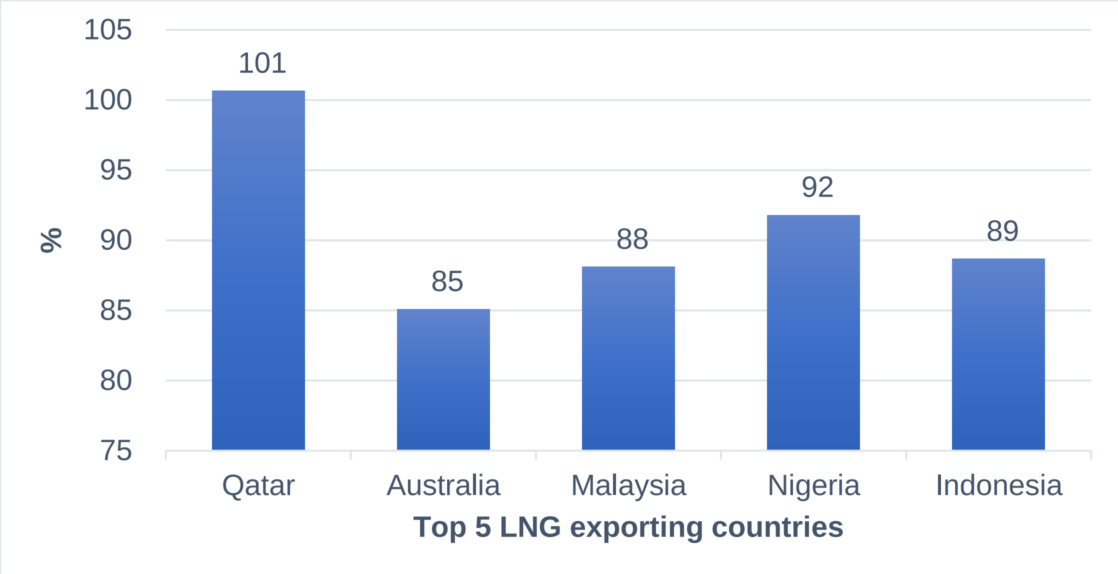
Figure 2.15: Ten-year investment in liquefaction capacity 2008-2017



Source: Adapted from GIIGNL (2018)

Assessing NLNG liquefaction train, the company has done remarkably well in terms of LNG trains utilisation, with respect to asset utilisation as a measure of SCFP. Out of the NLNG train capacity of 22.2 Mtpa, it produced 20.28 Mtpa in 2017, which shows 92% capacity utilisation (Figure 2.16). Amongst the big five, only Qatar has a better utilisation rate with 101%. The goal of liquefaction plant is to maximise utilisation without interruption (Berle *et al*., 2013; Berle *et al*., 2011).

Figure 2.16: Trains capacity utilisation as at 2017



Source: Adapted from GIIGNL (2018)

2.5.3 Liquefied natural gas storage

LNG storage is an important component in the daily operations of an LNG terminal (Werner *et al*., 2014). LNG is warehoused in large tanks at both the liquefaction facilities and the import terminals. At an export terminal, LNG is stored until it is loaded to a vessel for shipment and at an import terminal, LNG is stored until it is converted back into natural gas and sent out to consumers via pipelines (GIIGNL, 2014e). This study focused on storage at export terminal considering it is the value chain that is within the scope of NLNG is an exporter.

In an industry in which safety considerations are paramount, safe and secure storage is in part a function of the codes and standards which contribute to the operational integrity of an LNG operation (GIIGNL, 2014e). LNG tanks have multiple containment with the first layer being the tank which holds the LNG. The storage tanks are built with thermal insulation to prevent heat transfer, reduce evaporation, and protect the structure from cryogenic temperatures which could damage the structural integrity of the tank. Secondary containment is provided either by dikes, berms and impoundment dams around storage tanks, or by constructing a second tank around the primary storage tank to contain the LNG in the unlikely event of a failure in the primary tank. The decision to use a certain design is informed by available space and local requirements. The vast majority of LNG operators use surface tanks, although Japan has constructed some underground tanks to utilise expensive land, and there are some floating storage tanks at offshore receiving terminals (GIIGNL, 2014e). The features of LNG storage tanks are analysed below:

1. Single containment tank

A single containment tank is made of an inner cylindrical container made of 9% nickel steel. This inner container is surrounded by a carbon steel outer tank which holds an insulation material in the annular space. The outer tank is not designed to hold cryogenic materials, only the inner tank provides containment for the cryogenic liquid. However, single containment tanks are always surrounded by a dyke external to the tank which provides 100% secondary containment in the event of a failure of the inner tank. This is the most common type of tank around the world; it has an excellent reliability record, but does require a relatively large area of land (GIIGNL, 2014e).

2. Double containment tank

Unlike the single containment tank, the double containment tank has an outer wall usually made of post-stressed concrete instead of a containment dike. Should the inner tank fail, the secondary container is capable of containing all the liquid and vapours that might escape through the annular gap, which is the space between the tank and the concrete wall. The outer concrete wall increases the cost of the tank; however it requires less space because there is no need for a containment dyke. (GIIGNL, 2014e).

3. Full containment tank

A full containment tank is a double containment tank in which the annular gap between the primary and secondary tanks is sealed. Most of the LNG storage tanks built recently have been designed as full containment tanks. In this tank, the outer container is liquid and vapour tight, in case of leakage of the primary container, the secondary container remains LNG-tight. The secondary barrier wall is usually made of pre-stressed concrete and the roof is normally reinforced concrete, although under some circumstances metal roofs are utilised (GIIGNL, 2014e).

4. Membrane tank

The membrane LNG storage tank is composed of a post-stressed concrete tank with a layer of internal load-bearing insulation covered by a thin stainless-steel corrugated membrane. The concrete tank supports the weight of the liquid which is transferred through the membrane and insulation; the membrane is not self-supporting. The membrane has the capability to contract and expand with changing temperatures. Membrane tanks are not popular; they were constructed in France and Korea in the 1970's and 1980's (GIIGNL, 2014e).

5. In-ground tank

In-ground tanks are underground containments that are mainly used in Japan. In-ground LNG tanks were developed by Tokyo Gas Engineering (TGE) in the early 1970's based on earlier designs in the UK, the US and Algeria and subsequently used by other Japan and some other Asian countries. As of 2005, there were 61 in-ground storage tanks in Japan. The record for the largest LNG tank in the world was first set by an in-ground, 200,000 m^3, although several surface tanks have recently been built with a similar capacity. These tanks are more expensive and take longer to build than a surface tank, it takes about 4 to 5 years to build one compared to 3 years for a surface tank. The terminals with in-ground tanks are designed taking the surroundings into cognisance to ensure safety at every stage of the production process. These tanks do not need to be surrounded by a dyke or concrete wall, so the separation distance from adjacent land is less than that of other types of tanks (GIIGNL, 2014e).

A lot of investment and consideration has been given to LNG tanks due to the pivotal role they play in LNG. In over four decades, there have not been any incidents concerning LNG tanks that have had any impact beyond the terminal (GIIGNL, 2014e). Due to the huge cost involved in LNG tanks construction, efficient utilisation is essential to improve SCFP in NLNG. Typically, storage capacity covers a few days of operations with very limited flexibility to store for later months or peak seasons (Werner *et al*., 2014).

Table 2.2: Storage tank capacity utilisation

Country	Train capacity in Mtpa	Tank capacity (M^3)	Storage per Mt	Ranking
Qatar	77	2,340,000	30,390	3
Australia	65.3	2,228,000	34,119	4
Malaysia	30.5	390,000	12,787	1
Nigeria	22.2	336,800	15,171	2
Indonesia	21.1	1,140,000	54,028	5
Average			29,299	

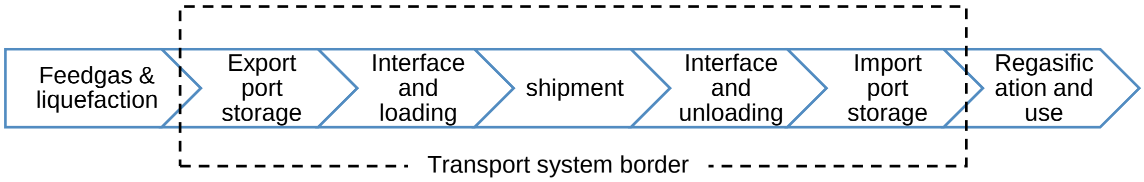
Source: Adapted from GIIGNL (2018: 24)

This study analysed storage tank capacity utilisation of NLNG and that of its competition by analysing storage capacity allocated to trains liquefaction capacity for each country. NLNG has an efficient storage tank utilisation of 15,171 m^3 per Mt of train capacity when compared to its competitors. This figure is better than the industry average of 29,299 m^3 and only 2nd to Malaysia's 12,787. This has influences for SCFP in LNG systems by minimising the cost of investing in additional capacity.

2.7.4 Liquefied natural gas transportation

LNG transportation occurs at all levels of the NLNG supply chain network; it is the systematic movement of product in from feedgas, liquefaction plant, storage, loading, export port/ship interface, shipping network, import port/ship interface unloading, import LNG storage, regasification to consumption. However, the LNG transport system boundaries are defined to be from the export harbour storage tanks to the import harbour import tanks (Berle *et al*., 2011)

Figure 2.17: Components and border of LNG transportation system



Source: Berle *et al*. (2011: 701)

NLNG cargoes are either sold under spot contract at the terminal or shipped using the company's vessels. Vessel routing determines how much transportation capacity a fleet of vessels can give. It is a highly discrete operation from an optimisation point of view. Matching transportation demand and total fleet capacity available, the former is determined from the amount of LNG to be transported and the travel time between each pair of terminals, while the latter is dictated by the number of owned and chartered vessels and their capacities, adjusted to reflect ballast voyages. Additional limitations can be added to specific terminals and vessel types to address compatibility issues such as buoy ports requiring vessels with on-board regasification facilities. Some LNG is lost during transportation due to boil-off such that volumes available for regasification are lower than volumes sent out from liquefaction (Werner *et al*., 2014).

The frequency of movement is dictated by supply and demand, the liquefaction plant should ideally run at 100% capacity to maximise profits. Similarly, final consumer demand that their gas needs are met, requiring stable deliveries. Performance optimisation in this system can be achieved in a situation where the export port storage never runs full and the import harbours never should run empty. The performance of the transport system is measured in either economic loss, time or volume unavailability. A single export port serves several customers (Figure 2.11), at any time serving a fleet of multiple vessels on long-term contracts (LTCs). Due to high capital investments in the liquefaction plant, a goal of operation is to minimise down time and the goal of the transportation planning system is never to require the LNG liquefaction plant to reduce production (Berle *et al.,* 2013). To meet the increased demand of natural gas, the capacity of the LNG fleet has increased considerably in the last decade (Andersson *et al*. 2016). The goal of investment in LNG fleet is to minimize tanker investment and associated OPEX (Koza et al., 2017).

Literature revealed that the ability to meet customer demand has significant influence in SCFP. Efficient transport assists in delivering LNG to target customers (Berle *et al.,* 2013; Berle *et al.,* 2011). Over the years, LNG exporters have channelled a significant portion of their investment into vessel capacity. NLNG disposed of six of its aging and smaller vessels in 2015 and replaced them with 6 newer and bigger capacity vessels between 2015 and 2016. This development will support reliable delivery of NLNG cargo to its customers around the world (Figure 2.11) and satisfy its LTCs obligation under delivery ex ship

(DES). NLNG via its wholly owned subsidiary, Bonny Gas Transport Company Limited (BGT) has invested significantly into its vessel capacity, it has 13 vessels, six of which are only three years old and the rest are all less than 15 years, with a total capacity on 2,030,874 m^3. However, these figures are still less than that of NLNG competitors, Qatar gas having 31 vessels with total capacity of 7,211,904 m^3, and Malaysia owning 27 vessels with capacity of 3,463,092 m^3 (Clarksons, 2017). Similarly, NLNG has a relatively smaller terminal capacity with only 2 terminals of drafts of 12.9m which berth vessels to a maximum of 145,000 m^3 (Table 2.3) largely due to the complexity of its channels.

Table 2.3: Terminal capacity

Terminal	Berths	LOA (m)	Draft (m)	Vessel Max (m^3)
Ras Laffan, Qatar	6	395	12.5	266,000
Bintulu, Malaysia	3	300	12.5	145,000
Bonny Island, Nigeria	2	300	12.9	145,000

Source: Clarksons (2016)

Despite the drop in LNG vessel construction costs due to economies of scale and specialisation, they are still more than double the cost of a crude oil tanker (Scheig, 2009). Furthermore, another aspect of transportation cost to take into consideration is that LNG shipping costs differ based on the ship's operating and amortisation costs, the volume of the cargo, the route followed and the distance transported (Scheig, 2009). Challenges such as the feedgas sabotage that led to force majeure at NLNG have a significant effect on the utilisation of terminals and vessels to achieve SCFP. In maritime transport supply chains, inefficiency occurs when a transportation system is weak or has a limited ability to endure, handle and survive threats and disruptive events that originate from both within and outside the system boundaries (Berle *et al.,* 2011) (Figure 2.17).

Another aspect of the LNG transport value chain is the tactical LNG inventory routing program (LNG-IRP). LNG-IRP is the routing and scheduling of vessels between liquefaction plants and regasification terminals. To transport the LNG between the loading and unloading terminals, the planners control a heterogeneous fleet of LNG tankers, with each ship separated into several cargo tanks. The ship is always fully loaded when departing the loading port, however, it is possible to unload a variable number of tanks at each regasification terminal. During a voyage some of the LNG evaporates into a gas, called boil-off, which is used as fuel. Some LNG is left in the LNG tanks to keep them cool except just before loading. The planning problem is to design routes and programmes for the LNG vessels including determining the production and consumption at all ports to maximise the throughput without exceeding the capacities of the LNG tankers, berth capacities and inventory limits at the storage tanks (Andersson *et al.,* 2016; Al-Haidous *et al.,* 2016; Shao *et al.,* 2015; Grønhaug *et al.,* 2010). An additional scheduling problem considered within the LNG business is the annual distribution program (ADP) structure. ADP constitutes the complete sailing schedule of the ships in the fleet for the coming year (Andersson *et al.,* 2016).

Major investment consideration in LNG transport is the fleet ownership. An LNG operator often employs one of three general strategies. First, the project company can purchase the vessel, adding shipping and operating costs to the total cost of the project, NLNG employed this strategy owned 13 vessels through Bonny Transport Company (Clarksons, 2017; NLNG, 2016). This provides the company with the most direct control over LNG transportation between liquefaction plant and regasification terminal. However, owning an LNG vessel, the company is exposed to many downside risks, such as direct liability in the event of an accident or spill. A direct purchase substantially increases the cost of the project.

The second approach is time-chartering of a new-build LNG vessel, which is a more common strategy for LNG projects. Research indicates that more than 85 percent of LNG trade globally is conducted with chartered vessels. NLNG has 10 vessels chartered and managed by their owners (NLNG 2016). The LNG operator acquires the right to use the vessel for an agreed period, paying the owner a fixed charge to cover the ship financing along with a variable charge, usually indexed against ship operating costs. Such an approach decreases project costs substantially and still provides the company with substantial control over the shipping activities. Lastly, a less common approach uses a contract of affreightment (COA), where the seller or buyer of LNG contracts with a shipping company to transport a certain quantity of LNG without designating a particular vessel. For buyers or sellers that cannot fit shipments into a designated number of vessels or that require flexibility in their delivery arrangement, a COA may be more appropriate. COA is commonly used for spot cargoes. However, the delinking of vessel and project limits the financing options for a shipping company, in turn this will keep the number of COAs to a minimum (Sousa and Flippen, 2005). An efficient transportation stream in the LNG supply chain involving safe, reliable and economical terminal handling and shipments using specialised LNG vessels from export terminal to import terminal, is necessary to optimise SCFP in NLNG.

2.8 Factors pertinent to NLNG supply chains

To address the research question and achieve the ultimate objective of this study to propose strategies and policies to improve SCFP, this study analysed factors that influence the value chains within NLNG supply chain systems.

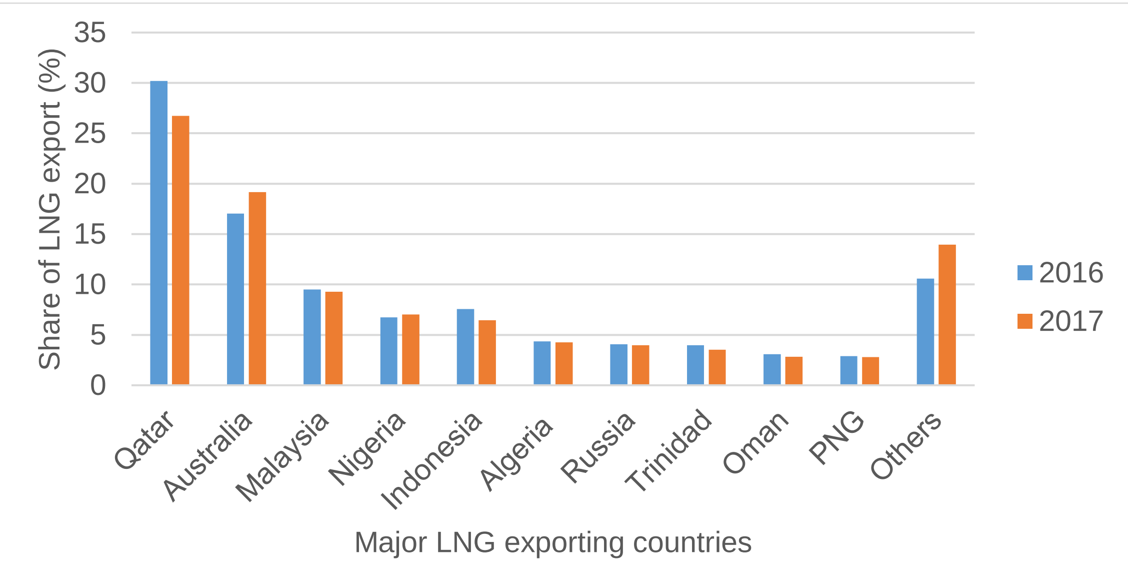
2.8.1 Key participants in liquefied natural gas trade

There are two major players that exclusively dedicate their operations to LNG production and distribution, namely the LNG producer/exporter and the LNG buyer/importer respectively.

Liquefied natural gas producers

The number of LNG exporting countries remained at 19 at the end of 2017, the same as in 2016. Qatar maintained its pole position in terms of LNG export despite the drop in market share from 30% in 2016 to 27%. During the same period, Australian export grew further from 17% to 19%, Malaysian LNG exports dropped from 10% to 9%, Indonesian volumes also fell from 8% to 6%, while Nigeria retained its 7% market share. These five countries combined exported 69% of global LNG exports in 2017 compared with 72% in 2016. Total LNG exports grew from 245 Mt in 2015 to 264 Mt and 290 Mt in 2017, which exhibited the growing demand for LNG (GIIGNL, 2018; GIIGNL, 2017; IGU, 2017) (Figure 2.18).

Figure 2.11: Liquefied natural gas exports 2016 versus 2017



Source: GIIGNL (2018); GIIGNL (2017)

Traditionally, Middle Eastern exporters are leading the Asia-Pacific and African exporters in terms of volumes supplied, due to the dominance of Qatar. This has slightly changed, and the change will be more pronounced by the turn of the decade, as growth projections incorporate new Australian projects. Australia's growth is supported by the country's favourable economic conditions coupled with its competitors facing several problems that could impede investment. These include rising domestic demand, ambiguous regulatory or energy policy, and economic and political instability (Nikhalat-Jahromi, *et al.,* 2017a). In the past decade, Australia saw investment in LNG projects of around USD 200B (OPEC, 2016). Another region that is making giant strides is North America, although the US currently plays a minute role in the global LNG industry, numerous projects have been approved for exports in the US. The first venture to materialise was Sabine Pass, which made its maiden shipment from Louisiana to Brazil in February 2016. Sizeable LNG projects are under development, with many targeting major Asian markets. As at 2016, investment of about USD 50B has taken place (OPEC, 2016).

In establishing LNG producing projects, once the viability is established, a group of companies and institutions are assembled to finance and develop the enterprise. This group usually includes commercial banks, multilateral lenders, export credit agencies, national oil companies (NOCs) and international oil companies (IOCs). The NOCs and the IOCs are usually the equity investors, while the others are loan providers (Jensen and Dickel, 2009). The equity holders usually develop the LNG supply enterprise in the form of a special purpose vehicle (SPV)/project company or through a non-incorporated JV company or a tolling company arrangement (Nikhalat-Jahromi, *et al.,* 2017a).

1. *Project company/special purpose vehicle structure*

This is a JV between an NOC and IOC(s) coming together as shareholders to form an SPV and appoint one of the partners (usually an IOC) to operate the SPV. Under this arrangement, the SPV purchases gas from the upstream gas suppliers, markets the LNG, enters into LTCs with the buyers and utilises the revenues generated for reinvestment or as dividend (Nikhalat-Jahromi, *et al.,* 2017a). Project company/SPV is the most popular type of LNG set up. In the project company arrangement and the non-incorporated JV arrangement, one of the sponsors is usually appointed to operate the enterprise. Nigeria, Trinidad and Tobago, Angola, Australia, Peru, Malaysia, Equatorial Guinea, Qatar, Russia, Yemen and Oman adopts the project company structure for LNG operations (Weems and Sulivan, 2005). In Nigeria, NLNG was incorporated as a SPV between NNPC as IOC and Shell, Total and Eni as IOCs. Shell was also appointed to operate NLNG (NLNG, 2016).

2. *The non-incorporated arrangement*

In the non-incorporated JV structure, each party owns a percentage of the LNG supply enterprise, delivers a proportionate quota of the feedgas to the enterprise, enters into an LTC with buyers based on its share of LNG, and is entitled to the revenues generated. In this arrangement, partners often enter into a joint marketing agreement through which one of the sponsors sells the LNG produced jointly (Weems and Hwang, 2013). The non-incorporated arrangement is adopted in countries where there is a legal framework supporting it, usually in enterprises where the host country does not want to take an active role and just imposes royalty and tax, or enterprises where the sponsors are not concerned with significant liabilities that may arise from the operations. Hence, there is no need to seek protection by establishing an SPV (Weems and Sulivan, 2005). Similar to the SPV set up, in the non-incorporated JV arrangement, one of the sponsors is usually appointed to operate the enterprise. Australia, Papua New Guinea, Norway, Indonesia and Alaska have adopted the non-incorporated JV structure (Weems and Sulivan, 2005).

3. Tolling company arrangement

The tolling company merely provides a liquefaction service to feedgas suppliers for a negotiated fee, it owns neither the feedgas received nor the LNG it produces. Gas supplier lifts, market and sells the LNG produced to buyers. The feedgas supplier commits to the LNG production capacity of the tolling company (Weems and Sulivan, 2005). This arrangement is not as common as the first two structures analysed above (Nikhalat-Jahromi, *et al*., 2017a). Egypt and Trinidad and Tobago occasionally use the tolling company arrangement (Weems and Sulivan, 2005).

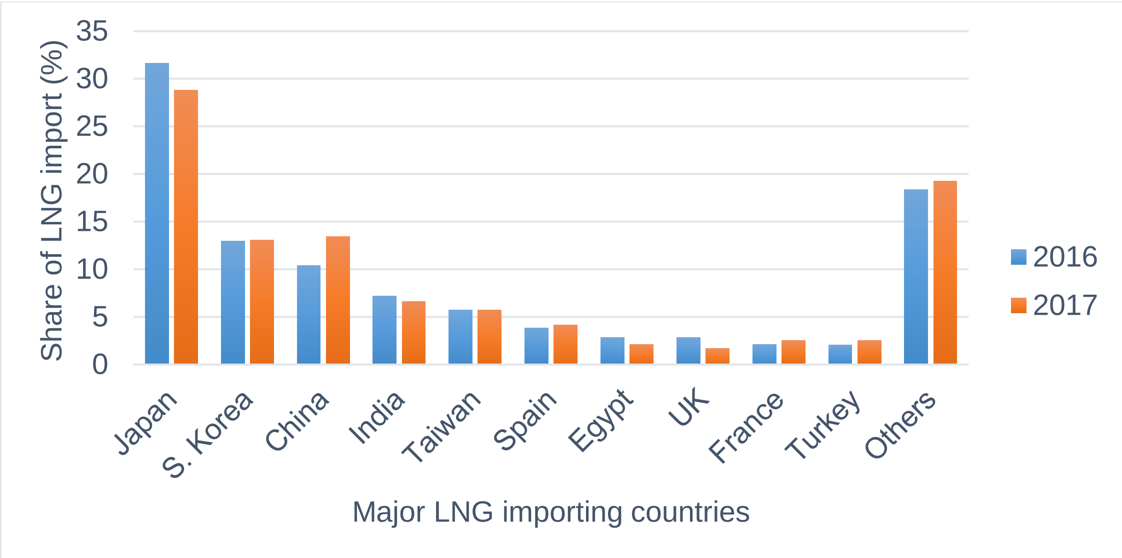
Although owners and executives of LNG companies are not categorised as a value chain within LNG systems (Figure 2.7), however, the decisions and actions they take impact every stream of the distribution systems. To maximise SCFP in NLNG it is necessary for JV partners to align their strategic goals, including SCFP strategies. LNG industry is vertically integrated, this requires market participant to build collaborative networks that will assist in cost reduction and maximisation revenues, assets, and working capital.

Customers: liquefied natural gas buyer

The number of LNG importing countries grew from 39 in 2016 to 40 in 2017. Out of the 40 LNG importing countries, Japan, China, South Korea, India, Taiwan and Spain are by far the biggest LNG importers, and in 2017 they imported a combined total of 208 Mt from 164 Mt of LNG in 2016, which is more than 72% of the world's LNG supply. Japan remained number one LNG importer, although

Japan's share of LNG cargo has dropped from 32% in 2016 to 29% in 2017 (GIIGNL 2018; GIIGNL, 2017) (Figure 2.19), Japan reached its peak of 74.5% in 1986 (Drewry, 2010).

Figure 2.19: Liquefied natural gas imports 2016 versus 2017



Source: Adapted from GIIGNL (2018; 2017)

The importer is the party on the other side of the LTC. These enterprises have traditionally been state-owned or regulated private utilities serving their domestic gas market. Just like the LNG producers, the buyers also raise money from commercial banks, multilateral lenders in the form of loans to develop an LNG receiving infrastructure (Nikhalat-Jahromi, *et al.,* 2017a).

LNG importers are not presented as a value chain within LNG distribution systems (Figure 2.7), however, their actions has significant influence on LNG SCFP. Strategic relationship and integration with LNG importers is necessary to understand each customer's need, meet their demand, increase market share, maximise revenue and to optimise SCFP.

2.8.2 Liquefied natural gas contracts

LNG is traded on either LTCs of 20-25 years or short-term transactions made up of spot and short-term contracts.

Long-term contracts

Traditionally, LNG trade has been based on LTCs since its commercialisation in the 1960s, these contracts consist of long or medium term sales of more than four years (GIIGNL, 2018), though LTC durations are usually between 20-25 years (GIIGNL, 2017). There are two parties to each contract, a producer who is normally the seller or exporter, and customer who is the buyer or exporter (Nikhalat-Jahromi, *et al.,* 2017a).

LTC is at the core of an LNG project; it is a sale and purchase agreement that establishes the rights and obligations of the parties involved. This agreement sets out responsibilities relating to the volume and the price of LNG between the producer and the buyer. LTC has significant impact on financial performance that is why it is the preferred choice of most LNG exporters, LTCs guarantee stable revenue over long periods of time, which can be used as a security to seek for external investment for project expansion. LTCs also allow for better strategic planning of operations. Transaction parties are locked into an agreed price, usually discounted for time-value for money, consequently, exporters stand to lose extra profit when LNG price increases in the future and will make abnormal profit when LNG price falls. The seller takes the price commitment while the buyer takes the volume commitment. The following are key underlining features and clauses under the LTCs (Hartley *et al.*, 2013; Greenwald, 2006):

1. *Shipping arrangement*

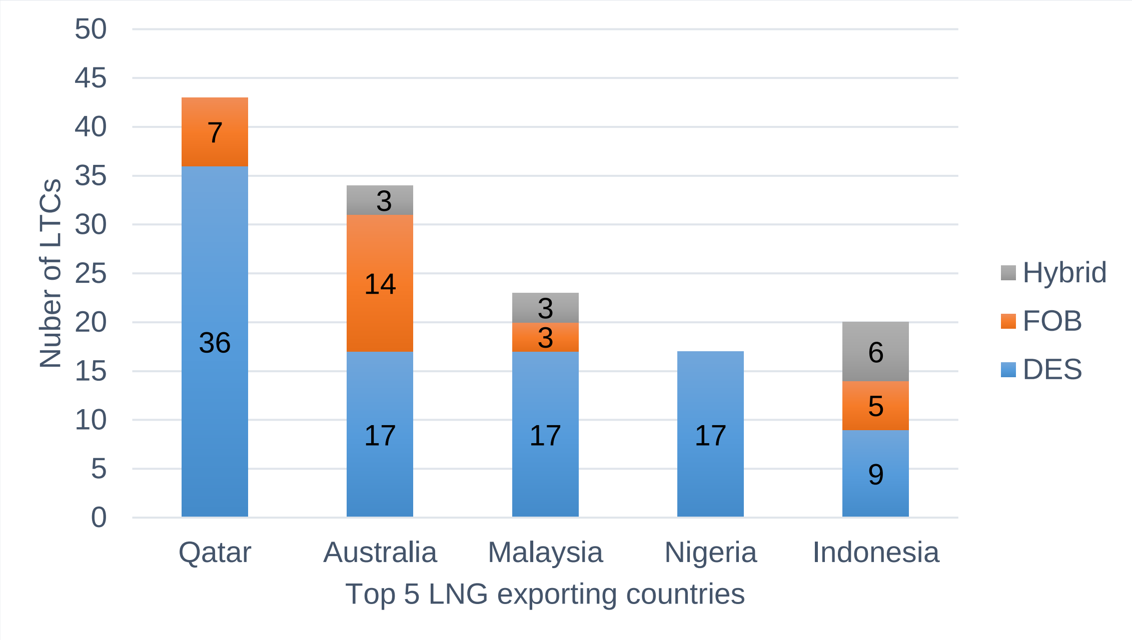
There are three types of shipping arrangements in LTC, which are derived from international commercial terms (incoterms), including DES, free on board (FOB), and hybrid, which combines both DES and FOB.

In DES, LNG producer delivers when LNG cargo is placed at the disposal of the buyer on board the ship, not cleared for import at the agreed port of destination. The exporter bears all costs and risks in bringing the cargo to the agreed port before discharging. DES is the most widely adopted arrangement in LTC; it enhances efficiency in inventory management, production and turnover. NLNG employed DES in all its 17 LTCs (Figure 2.20). Although the cost of shipment is added to LNG price in DES, the arrangement requires significant initial investment into vessel capacity by LNG exporter.

FOB means that the LNG exporter delivers the cargo on board the vessel nominated by the buyer at the named port of shipment. The risk of loss of or damage to the cargo passes when the LNG is on board the vessel, and the buyer bears all costs from that moment onwards (ICC, 2018). NLNG does not have a single LTC under FOB, and FOB is not very popular in other key LNG exporting countries, with the exception of Australia that has 14 FOBs out of its 34 LTCs (Figure 2.20). This could be associated with the rapid expansion of Australian LNG liquefaction capacity without commensurate investment into its shipping capacity and also all Australian cargoes are delivered to the nearer Asian market, with close to 50% going to Japan, a country with significant investment in LNG vessel capacity (GIIGNL, 2018; Clarksons 2017).

Some LNG exporting countries such as Indonesia, Malaysia and Australia adopted a hybrid of DES and FOB in very few of their LTCs (Figure 2.20) to give flexibility to both LNG buyers and sellers in terms of vessels availability. These incoterms have become an essential part of trade (ICC, 2018). They provide rules and guidance to LNG importers and exporters.

Figure 2.20: Incoterms for liquefied natural gas trade



Source: Clarksons (2017: 52; 53; 54; 55)

2. Commodity quality and quantity clause

The quality and quantity of LNG to be delivered is agreed and stated in the contract and it explains what happens if one of these conditions is not fulfilled (Nikhalat-Jahromi, *et al.,* 2017a).

3. The destination restriction clause

The LNG exporters traditionally insert a destination restriction clause (DRC) in LTCs, precluding buyers from reselling LNG cargoes on the open market (Lloyd's List, 2017). The DRC is a territorial restriction intended to protect market separation by the LNG buyer (Nikhalat-Jahromi, *et al.,* 2017a). The DRC gives the LNG producers the ability to influence the LNG market and restricts shipping routes to a fixed voyage from loading port to discharge port (Lloyd's List, 2017).

The LTC specifies the delivery terminal of the LNG shipment; it prohibits a buyer from selling an LNG cargo, which is to be delivered to the principally agreed regasification terminal (Nikhalat-Jahromi, *et al.,* 2017a).

The European and US exporters have liberated their regional LNG market through the removal of the DRC from their LTCs, which was done to increase competition and boost liquidity in the market. The DRC is also under much scrutiny in Asia. In June 2017, Japan's anti-monopoly commission has ruled against the insertion of this clause in LNG LTCs, setting the stage for changes in LNG trade patterns. The Japan Fair Trade Commission issues that when LNG sellers conclude a new contract or revise one at expiration, monopolistic clauses or trade practices which lead to resale restrictions should not be included. The ruling also extends to the existing contracts before their expiration, advising that LNG sellers should at least review competition restraining trade practices. The agency states that it will monitor the LNG market and take stringent actions against any abuses and the Anti-monopoly Act. Although the ruling was not legally binding, it signals that DRCs were on the path to extinction in Asia, in a similar fashion which Europe took a decade ago. China and South Korea are expected to follow this practice (Lloyd's List, 2017).

The exclusion of this clause will have a major impact on LNG shipping. In the short-term, it is likely to cause disruptions in LNG trade, as importers such as Japan who bought 29% of global LNG supply including 1.52 Mt from Nigeria in 2017 (GIIGNL, 2018) will have the right to exercise arbitrage opportunities diverting Atlantic Basin LNG cargoes such as NLNG's (GIIGNL, 2017) to nearer markets, essentially Europe or the Middle East, and import closer cargoes from Australia or Malaysia. Furthermore, elimination of DRC from the LTCs by Japan could cause some disruption in the market as diversion of sailing cargoes may result in technical mismatches and increase the risk of accidents or the ruling resulting in contract disputes and renegotiations (Lloyd's List, 2017). However, in the long-run, the removal of DRC will help to liberate the LNG trade and open up the market for non-traditional participants. "As the market grows, demand for LNG shipping should also grow" (Lloyd's List, 2017).

4. *Take-or-pay provision*

LTC's take-or-pay clause makes it mandatory for the buyer to take certain volume of LNG cargo as a minimum each year and obliges the buyer to pay for that minimum quantity as long as it is available, whether it is actually taken or not (Hartley *et al*., 2013; Davey, 1997). Generally, more than 90% of the annual production of a liquefaction plant is tied to this clause and the remainder sold on spot (Jensen, 2004).

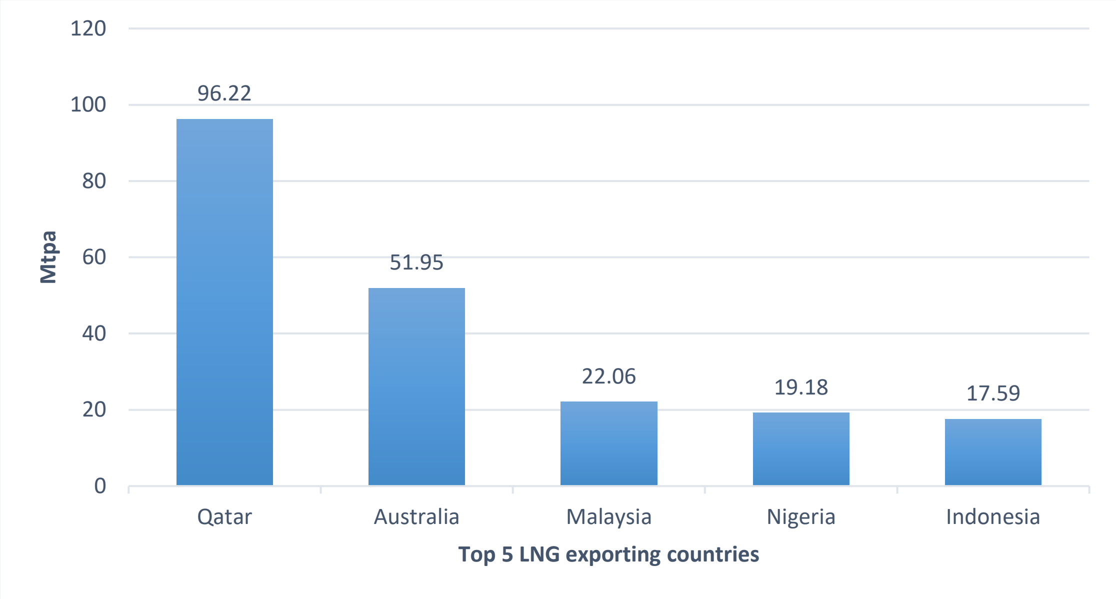
5. *Price of the liquefied natural gas*

Price is an important factor in securing the sustainability of an LNG project. Conventional LTCs do not have a fixed price over the life of the contract, but rather they usually have a formula that relates the price of the cargoes to competitive energy sources at the time of delivery to the destination. Sometimes a minimum price and a maximum price are set, the former to protect the producer from a drastic fall in LNG price and the latter to protect the buyer from stern increase in product price (Nikhalat-Jahromi, *et al.,* 2017a; Hartley *et al.,* 2013).

The philosophy behind the use of LTCs in projects that involve significant amount of capital expenditures like LNG is that the nature of contract provides some level of security to the LNG company's lenders. For example, the take-or-pay provision assures the lenders a minimum income that will be generated by the LNG enterprise over the LTC lifetime which should cover the debt and its associated costs (Greenwald, 2006). During the credit negotiations between the LNG company and its lenders, the latter usually ask for copies of the proposed or existing LTCs and transport agreements as proof before granting or disbursing of funds for the project. After assessing the LTC, the lenders also evaluate the creditworthiness of the buyers to consider whether the buyer can fulfil its obligations, which have direct impact on the LNG company's cash flow and subsequently debt financing. LTCs are equally as important for the buyers because it will show their lenders that stable LNG supply is guaranteed, which would be sold to generate cash flows that will be utilised for debt repayment (Nikhalat-Jahromi, *et al.,* 2017a).

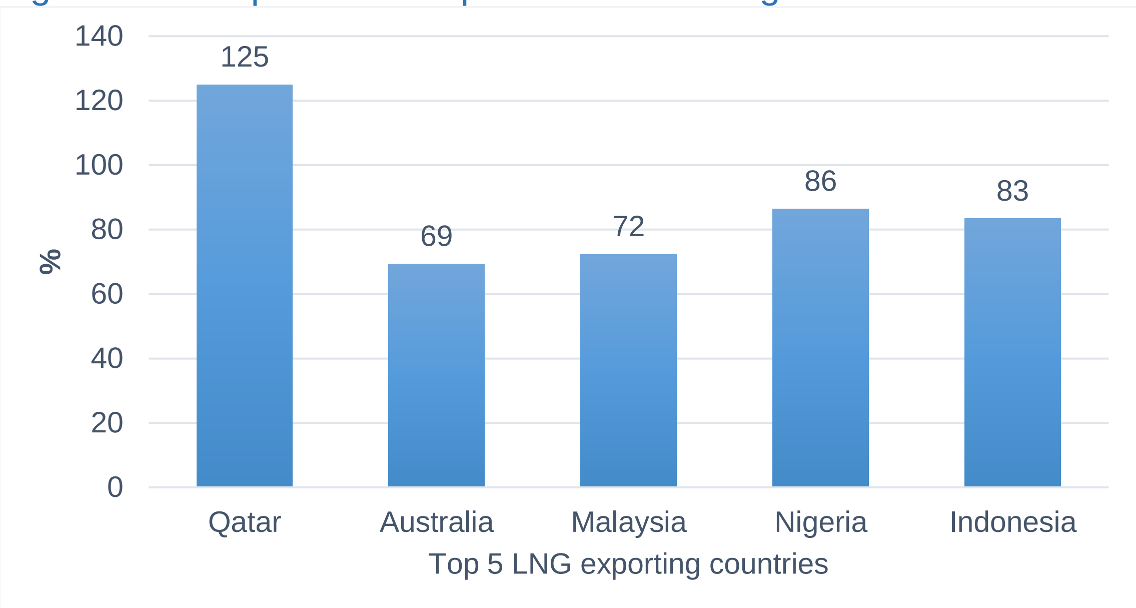
Like any major exporter, NLNG is a major participant in LTCs, as at 2017 it has 17 LTCs totalling 19.18 Mtpa (Figure 2.21) representing 86% of NLNGs total liquefaction capacity of 22.1 Mtpa. Only Qatar has a higher percentage of LTCs with 125%, which can be challenging for Qatar considering it has pledged to deliver more than its liquefaction capacity. Indonesia, Malaysia and Australia have 83%, 72% and 69% of their liquefaction capacity committed to LTCs respectively (Figure 2.22). Analysis showed that the performance of NLNG in LTCs is encouraging which facilitates financial performance in terms of revenue growth and asset utilisation.

Figure 2.21: Long-term contracts as at 2016



Source: Adapted from Clarksons (2017: 52; 53; 54; 55)

Figure 2.22: Liquefaction capacities tied to long-term contracts



Source: Adapted from Clarksons (2017: 52-55)

LTCs have dominated the international market for LNG since its inception (Hartley *et al.,* 2013) and have maintained its dominance (Nikhalat-Jahromi, *et al.,* 2017a). However, since the year 2000 the proportion of LNG-traded on spot or under short-term contracts has grown considerably. LTCs between exporters and importers of LNG have the benefit of reducing cash flow variability and thereby increasing the debt capacity of large, long-lived capital investments for both the exporter and the importer. LTC increases leverage which in turn reduces finance cost. However, LTCs restrict the ability of the participants to take advantage of profitable short-term trading opportunities (Hartley *et al.,* 2013).

Short-term transactions

International gas trade is experiencing new methods of operation in the form of short-term and flexible (Mazighi, 2004). Short-term transactions in the LNG market are divided into the spot and short-term contracts. Short-terms contracts are contracts of less than four years duration (GIIGNL, 2018; Hartley *et al.,* 2013). The contract may comprise a series of LNG cargo sales based on a short-term contract (Jensen, 2004). “Pure spot” are trades whereby cargoes are delivered within three months of the transaction date. Pure spot reached approximately 20% of total volumes delivered in 2017, representing about 59 Mt. Spot imports were facilitated by LNG contracts with destination flexibility, by increased contracting for portfolio trade and by the growing volumes handled by traders. Destination flexibility is an important factor for LNG supply chain participants (Rodríguez, 2008). Asia received about 60% of spot LNG with 35.4 Mt in 2017, followed by Europe with 9.0 Mt, the Americas with 8.6 Mt and the Middle East did 5.5 Mt. The largest growth in spot imports came from China and South Korea, who imported 21% and 22%, respectively, of their LNG supplies on a spot basis in 2017 (GIIGNL, 2018). There are some major differences between the short-term transactions and LTCs, which include the following:

1. Take or pay provision

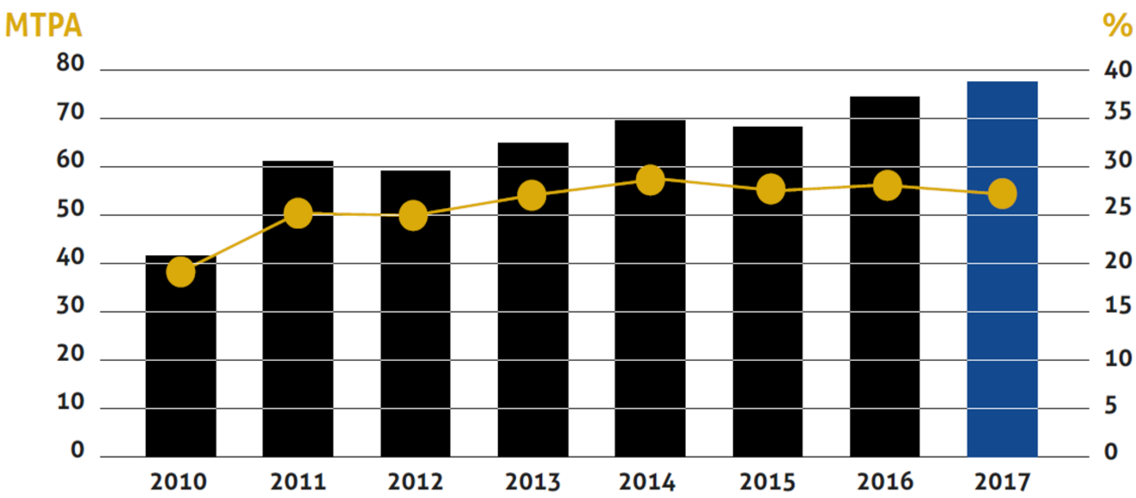
There is no take or pay clause in spot sales due to the simultaneous nature of the transaction (Hartley *et al.,* 2013). Although a take or pay clause might still exist in the short-term contract, it does not cover the volume risk over the life of the loan provided by the lenders for an LNG project development due to the short tenure of the sales contract (Nikhalat-Jahromi, *et al.,* 2017a).

2. Fixed price

LNG spot price is not fixed, the spot price is based on the prevailing market price at the time of the transaction (Hartley *et al.,* 2013). Under a short-term contract, the price might be fixed, however, it will be very close to the spot rate due to the shorter duration of the contract (Nikhalat-Jahromi, *et al.,* 2017a).

The prominence of spot sales in the LNG sector has grown in recent years (GIIGNL, 2017; Nikhalat-Jahromi, *et al.,* 2017a), since the turn of the millennium the proportion of LNG traded on spot or contracts of less than four years duration has risen substantially (Hartley *et al.,* 2013). In the year 2017, 77.55 Mt of LNG was traded on a spot or short-term basis, which represents 27% of total NLG traded volume. This share of spot and short-term cargoes has remained stable for three years in succession, and could increase further in the coming years (GIIGNL, 2018; GIIGNL, 2017) (Figure 2.23).

Figure 2.23: Share of spot and short-term market versus total trade

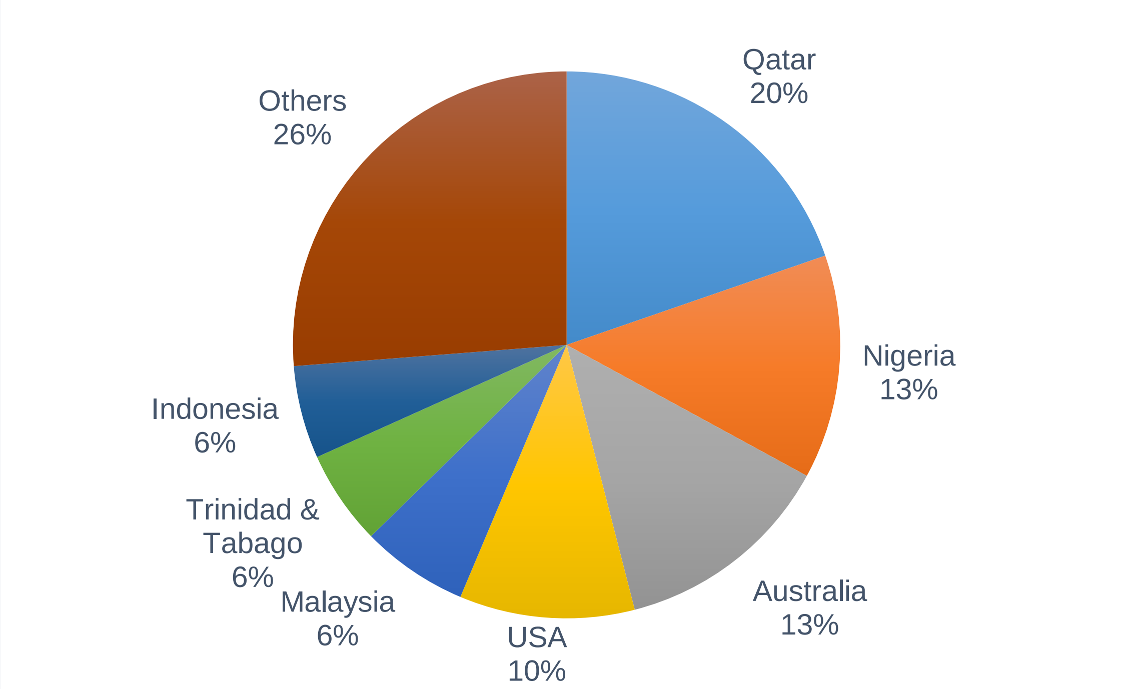


Source: GIIGNL (2018)

The rise of spot and short-term volumes was principally influenced by the development of US exports, which accounted for 10% of LNG volumes delivered under short-term contracts in 2017. Qatar saw its share of this market decrease from 27% in 2016 to 20% in 2017. However, amongst the LNG suppliers, Qatar remains the main source of spot and short-term volumes to global markets in 2017, followed by Nigeria with 13%, and Australia rose to 13% during this period from 9% in 2015 thanks in part to the surge in cargo volumes from its new trains (GIIGNL, 2018; GIIGNL, 2017) (Figure 2.24). On the demand side, China and South Korea showed the highest growth in spot and short-term imports, recording increases of 3.0 Mt and 4.1 Mt respectively. Japan experienced the largest decline in spot and short-term trade of -2.8 Mt, despite total imported volumes being stable, followed by Jordan with - 1.9 Mt and the United Arab Emirates (UAE) with -1.7 Mt.

Spot and short-term imports increased by 2.1 Mt and amounted to 77.6 Mt in 2017 compared to 75.5 Mt in 2016. The share of spot and short-term imports in total LNG imports remained the same at around 27%. NLNG remains a major player in the spot market, which gives the company the opportunity to take short-term advantages of market variabilities to improve its financial performance. The fundamental challenges associated with spot contract are volume, price, and infrastructure risks (Mzighi, 2004).

Figure 2.12: Share of spot and short-term market in 2017



Source: GIIGNL (2018)

Current trends indicate an evolution towards more flexibility in the NLG trade, and the commercial patterns are evolving as destination free volumes increase and as new buyers and sellers join the market. There are two major factors behind the emergence of the spot sale, which are spot sale of uncommitted product, which is cargo which is not sold on LTC and arbitrage.

1. Spot sale of uncommitted volume

The causes of uncommitted volume include, first, surplus capacity during ramp-up period of the LNG projects, which is the gap period between the start of LNG production to the agreed time of delivery to the contracted buyers. Second, increases in capacity of older liquefaction plants. Third, production after the initial LTCs expire. Last, a proportion of a plant's output that is not contracted and specifically dedicated to spot sales (Jensen, 2004). The latter is not a popular industry practice, as it constitutes less than 10% of the NLG spot market share (Nikhalat-Jahromi, *et al.,* 2017a; 2016).

2. *Arbitrage spot sale*

The current LNG industry practice gives room for the LNG cargoes on LTCs to be diverted to other markets distinct from the originally contracted destinations with mutual agreement between the seller and the buyer for cargoes to be sold on LNG spot (Zhuravleva, 2009). Arbitrage opportunities are explored for either commercial or operational motives. A commercially motivated arbitrage is targeted towards optimising return on investment (ROI), consisting of cost minimisation and/or revenue maximisation. Otherwise, arbitrage might be facilitated for operational reasons such as tank-full storage, regasification terminal outages, trade restrictions and instabilities in original destination countries. In this situation, the driver for arbitrage is not higher ROI, but rather circumstantial factors that lead to the diversion of LNG cargo (Nikhalat-Jahromi, *et al.,* 2017; 2016).

Three distinct parties can initiate arbitrage opportunities. First, the producer as the arbitrageur, where the producer proposes the arbitrage and offers to share the margin of arbitrage with the buyer. The exporter may have to replace the cargo diverted for arbitrage opportunities to satisfy the volume of the existing LTC. Second, the buyer as the arbitrageur, where the buyer proposes the diversion of the cargo to another market and offers to share the arbitrage margin with the supplier. Last, an independent trader as the arbitrageur, where an independent trader or investor buys the LNG cargo or acquires the right to divert the product. This trader might need to replace the cargo to fulfil the volume requirement of the LTC. The independent trader would have to share the margin with the seller and the buyer of the existing LTC (Zhuravleva, 2009). Pirrong (2017) established that in the future buyers and sellers will rely on shorter-term contracts, and the existing LTCs will be linked to spot LNG prices rather than crude oil. Consumers and producers will also benefit from more flexible pricing that more accurately reflects rapidly changing fundamentals of supply and demand. LNG spot trade will increase and give rise to a competitive and globally unified LNG market (Nikhalat-Jahromi, *et al.,* 2017b).

2.8.3 Liquefied natural gas price

Currently there is no uniform price for LNG. LNG price varies from one market to another (Nikhalat-Jahromi *et al.,* 2017a). Prices in continental Europe, Northeast Asia, India and China in LTCs are connected to other competing energy prices. These prices are negotiated between buyers and sellers who want to get the highest possible return for their investment as well as for the depletion of their national resources in the case of NOCs. In western countries like the UK and the US, prices are determined by competition among suppliers in a liberalized LNG market (Dickel *et al,* 2007).

Liquefied natural gas price in the United States and Europe

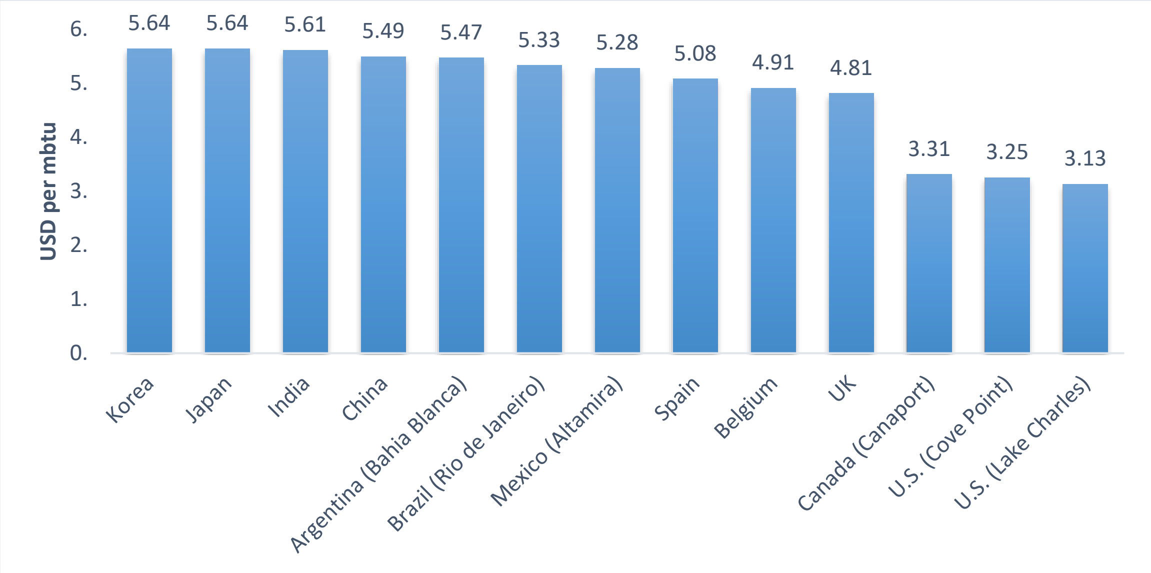
In the UK and the US, LNG prices are linked to the gas market indicators, consisting of Henry Hub and the National Balancing Point respectively (Nikhalat-Jahromi, *et al.,* 2017a). However, in most parts of Continental Europe the price of oil products and coal became the reference point for LNG price (Mukherjee and Panandiker, 2014). As a result of increasing competition from pipeline gas in the Continental Europe, the indexation pattern for LNG follows the same structure as on-shore gas and the developments regarding gas market liberalisation in the region is making LNG pricing more competitive (Nikhalat-Jahromi, *et al.,* 2017a).

Liquefied natural gas price in Asia

Japan is the major importer of LNG at it has significant influence on LNG price especially in Asia. The importation of LNG to Japan began as early as the 1960s during the electricity utility industry evolution. The policy objective at that time was to reduce oil imports, replacing oil with LNG to generate electricity became a priority. The price of oil became the reference point for LNG price in Japan (Jensen and Dickel, 2009). The Japanese pricing formulae for LNG LTCs are linked to oil prices of the LNG exporting country. However, since 1987, the majority of Japanese LTCs have been based on the JCC crude oil price. Subsequently, South Korea and Taiwan adopted the JCC when they became active in the LNG market. Generally, in the South and East Asian region, the JCC is the mainstream LNG pricing method (Energy Charter Secretariat, 2008).

The high oil prices between 2011 and 2014 when crude oil averages USD100/ barrel of crude oil (bbl) (Nasdaq, 2017) (Figure 2.8) produced a price gap when using benchmarked LNG pricing, especially concerning Asian prices that are linked directly to oil prices against the rest of the world. The emergence of this gap raised concerns in Asia, as high LNG prices have a negative effect on the competitiveness of industries in the region, particularly Japan, that rely heavily on LNG as a source of energy. This prompted the Asian LNG importers to begin to develop strategies to achieve a better LTC pricing formula (Rogers and Stern, 2014). However, in the light of the decline in oil prices between 2014 and 2017 (Figure 2.8), the desire to revise the pricing formula in the Asian LNG market has subsided. The LNG spot prices in the US and the UK follow their corresponding gas market indicators, while the LNG spot prices in continental Europe and Asia could be higher or lower than LTCs prices, because the spot prices are not linked to such indicators (Nikhalat-Jahromi, *et al.,* 2017a). For an LNG exporter the price of its importing country will have significant impact on its revenue and financial performance (Figure 2.25).

Figure 2.13: Import prices of LNG as of May 2017 by countries



Source: Adapted from Statista (2018b)

2.8.4 Liquefied natural gas regulations

Despite the investment opportunities in Africa's oil and gas market, entrants often face legal risks that pose threats to the economic viability of oil and gas investments. These challenges include resource nationalism; lopsided contractual provisions that confer unfair advantages on NOCs' arbitrary change in contract terms; delays in operational approvals, complex local content requirements and corruption potentials. If not addressed, these risks may erode any economic benefits in oil and gas investments (Olawuyi, 2015). Legal restrictions promulgated by government authorities, contractual obligations, industry standards are guidelines which govern how business activities such LNG operations should be conducted. Adherence or otherwise to regulations have financial consequences such as compliance fees and non-compliances fines and claims which can significantly affect SCFP in NLNG systems. The most significant regulatory requirement for the industry is to safely process, store and transport LNG. There are several guidelines and requirements which are designed to assure the safe operation of onshore and offshore LNG facilities, personnel and vessels. According to the GIIGNL (2014d: 1) stringent compliance with regulations, codes and standards has led to the LNG industry's exemplary safety record. Adhering to best practices through non-for-profit trade organisations has also helped to strengthen the safety philosophy of the entire industry. LNG vessels must comply with all relevant local and international regulatory requirements including those of the International Maritime Organisation (IMO), International Gas Carriers Code (IGC) and the US Coast Guard (USCG). Regulatory authorities are committed to reducing the risk of adverse environmental consequences, damage to equipment, facilities or vessels, and most importantly human health and wellbeing, which are achieved through various means in different parts of the world (GIIGNL, 2014d: 1).

Liquefied natural gas codes and standards

The LNG industry complies with international set of codes and standards, which stipulate safe technologies, materials and designs for the construction of an LNG terminal. Codes and standards allow the industry to implement approved technologies and ensure a high safety level. The development and implementation of these codes and standards promotes sharing advanced technologies and research. Primarily, European and American standards are widely employed throughout the world. Compliance with supplementary codes and standards may be required in certain countries (GIIGNL, 2014d).

An international work group called TC67 Work Group 10 is in charge of standardisation for installations and equipment for LNG, excluding product or testing' was constituted in 2006 under International Standardisation Organisation (ISO). Its objective is compatibility and harmonisation of LNG codes to enhance the existing codes and standards among countries to an international accepted level. The major codes are NFPA59A or EN1473 which provide robust construction requirements for protection against earthquake forces. Under these codes, all companies must undertake activities such as site-specific checks to determine ground motion risks and determine seismic characteristics. This investigation will identify the Probabilistic Maximum Considered Earthquake (MCE) (GIIGNL, 2014d). Compliance with these codes will go a long way to minimise risk of accidents, which could result in significant financial loss due to injuries, loss of asset, shutting down and claims or damages to LNG networks.

Nigerian regulations

Nigeria LNG being a company registered in Nigeria must comply with the provisions of Company an Allied Matters Act (CAMA) 1990. Other Nigerian regulations and policies applicable to NLNG are as follows:

1. Nigerian Ports Authority (NPA) Act 1999

Due to the NLNG shipping operations in Nigerian waterways, its shipping value chain is subjected to guidelines such as NPA petroleum wharf bye-laws under section 57, subsections 21 to 33. These subsections provide safety guidelines for loading and discharge of LNG vessels at terminals.

NPA (pilotage boards) order under section 61, subsection 15 states "pilotage shall be compulsory for every ship exceeding ten tons gross tonnage entering, leaving or changing its berth within the following districts:

a) *the whole of the pilotage district of the port of Lagos established under the NPA Pilotage District Order; and*

b) *the pilotage district A, B, C and D of the port of Port Harcourt established under the NPA (Pilotage Districts) Order* (Nigerian Ports Authority Act, 1999).

2. Nigeria LNG (fiscal incentives, guarantees and assurances) Act 1990

Nigeria LNG Act confer pioneer status on NLNG within the provisions of Industrial Development (Income Tax Relief) Act and exempt the company from certain taxes, custom duties, other levies and provisions of Pre-Shipment Inspection of Imports Act and to provide for the guarantees and assurances by the Federal Government to the company and its shareholders.

> *Notwithstanding the provisions of section 10 of the Industrial Development (Income Tax Relief) Act, the tax relief period of the company shall commence on the production day of the Company and shall continue for a period of ten years, so however that the tax relief period shall terminate at the first anniversary date after the first five years when the cumulative average sales price of LNG reaches 3 USD/mmbtu …* (Nigeria LNG Act, 1990: N87-1).

Tax incentives are the most successful method of attracting FDI into Nigerian oil and gas sector. However, without political stability, rule of law and deregulation or trade liberalisation, tax regimes alone cannot produce the desired performance required of the industry towards economic growth and development (Osimiri, 2002). An effective fiscal regime and regulatory process, trustworthy and transparent processes that effectively manage risks are necessary to maximise the national benefits of LNG developments (Grafton and Lambie, 2014). Hassan and Kouhy (2015) established factors that lead to oil and gas companies' non-compliance with environmental accountability, which include weak regulatory framework; non-recognition of the host communities as key environmental stakeholders; and non-recognition of the Nigerian public as environmental stakeholders.

Bermuda flag regulations

The BTG vessels that constitute the shipping network in NLNG systems carry a Bermuda flag. This makes it necessary for NLNG network participants to comply with Bermuda Shipping and Maritime Authority guidelines, including health and safety requirements. Bermuda Merchant Shipping Amendment Act (2018) subsections (2) and (4) provide that:

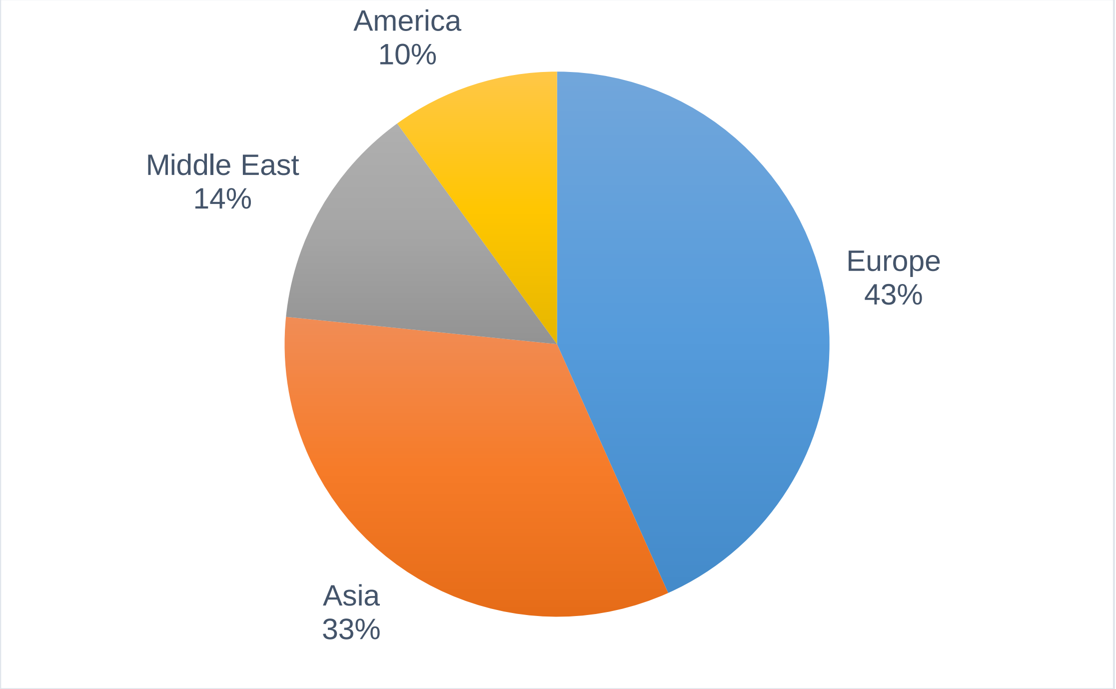
> *"If there is a relevant discharge (discharge of oil from ships into certain Bermuda waters), then the following persons commit an offence-*
>
> *a) the owner or master of the ship, unless he proves that the discharge took place and was caused as mentioned in paragraph (b);*
>
> *b) if the discharge from the ship takes place in the course of a transfer of oil to or from another ship or a place on land and is caused by the act or omission of any person in charge of any apparatus in that other ship or that place, the owner or master of that other ship or, as the case may be, the occupier of that place".*
>
> *"A person found guilty of an offence under this section is liable on summary conviction, to a fine of $500,000 and on conviction on indictment, to a fine of $1,000,000.*

Any fine or conviction assigned to a BGT vessel will have influences for BGT financial results and subsequently NLNG financial performance as a parent company to BTG.

European liquefied natural gas regulations

In Europe, LNG project applicants are mandated to perform a safety risk assessment in line with accepted guidelines and submit the outcomes of these studies to relevant authorities for review (GIIGNL, 2014d). European conventions typically focus on the results, rather than the specific method used to achieve the desired level of safety. European Council Directive 96/82/EC (SEVESO II) was established for the prevention of major mishaps concerning dangerous substances, including the LNG, and the minimisation of such impacts. The provisions of the Directive were developed following a fundamental review of the implementation of Council Directive 82/501/EEC (SEVESO I). Certain areas were specifically identified in which new provisions appeared necessary on the basis of an investigation of major accidents which had been reported to the Commission since the implementation of SEVESO I. The Directive sets out basic principles and requirements for policies and management systems that are suitable for the prevention, control and mitigation of major accident (GIIGNL, 2014d: 2). Europe as a continent is the biggest outlet for NLNG cargoes (Figure 2.26). Amongst the top 5 LNG exporting countries, NLNG is the 2nd exporter to European countries which is only bettered to Qatar. Out of the total 20.34 Mt exported by NLNG, 8.81 Mt was delivered to eight European countries (GIIGNL, 2018). DES is the dominant contract for NLNG exports, which means that LNG has to be delivered to its destination in NLNG vessels. NLNG must comply with all safety policies and procedures as specified by European Council Directives when delivering its product to any European country to optimise financial performance in NLNG supply chains.

Figure 2.14: NLNG exports to continents



Source: Adapted from GIIGNL (2018)

The United States liquefied natural gas regulations

In the US, the conventions do not provide formal methodologies for risk assessments; risks are evaluated by both the project applicant and regulatory authorities using regulatory guidance to target the precise issues, which risk assessments should address. LNG facilities are supervised by three government agencies, under an interagency agreement (GIIGNL, 2014d).

1. Federal Energy Regulatory Commission (FERC)

The FERC gives federal approval for the siting and the development of new onshore infrastructure and implements its authority over onshore facilities via the agency's guidelines. It is the responsibility of the FERC to issue a certificate to an LNG facility and is the prime federal agency that evaluates environmental and safety issues, including public concerns and review of procedures (GIIGNL, 2014d).

2. United States Department of Homeland Security (DHS)

The US Coast Guard (USCG) of the DHS has regulatory authority over LNG activities, which affect the safety of port areas and navigable waterways. The USCG also establishes review measures for evaluating any proposed deep-water port (GIIGNL, 2014d). A prime regulation governing the marine portion of an LNG terminal is 33 CFR Part 127, waterfront facilities handling LNG and liquefied hazardous gas. LNG terminals are run under site-specific USCG Operating Plans (OPLANS). The OPLANS entail pre-arrival boarding and examination including vessel certificates, crew licenses, safety equipment, vessel condition, vessel's log and procedures. Entry to any US port or terminal can be denied at the USCG discretion (GIIGNL, 2014d).

3. The United States Department of Transportation (DOT)

The Pipeline and Hazardous Materials Safety Administration (PHMSA) of the DOT is charged with the dissemination and enforcement of safety regulations and standards for both the transportation and storage of LNG and for interstate or international trade under the pipeline safety laws. The Maritime Administration (MARAD), also within DOT, is the authority in charge of granting license for the construction and operation of deep-water ports, including offshore floating import terminals. Contained in 49 CFR Part 193, LNG facilities are the Federal safety standards and applicable PHMSA regulations for LNG import terminals and storage facilities (GIIGNL, 2014d).

Some states in the US have LNG-specific regulations, which permit and review activities of operators, which tend to address local concerns. However, most states have regulations and permit requirements, which are similar to the federal regulations (GIIGNL, 2014d).

Over, the last 2 decades, the US was one of the major importers of LNG. However, there was a paradigm shift in the last couple of years, with significant investment into the US liquefaction capacity. The country exported 2.64 Mt in 2016 and 12.24 Mt in 2017, which shows a growth of over 460% over a period of one year (GIIGNL, 2018; GIIGNL, 2017). At this rate, the US will be one of the major LNG exporters by the turn of the decade; it is only Australian LNG exports that are growing faster US LNG exports. Despite these developments in the US, the country still imported LNG from Nigeria and Trinidad and Tobago in 2017, with NLNG exporting 0.14 Mt to the US during this period under spot contract, and NLNG does not have to use its vessels under spot sales (GIIGNL, 2018). This mitigated the financial risks associated with NLNG ships breaching any of FERC, DHS, DOT regulations in the US waters and LNG terminals.

Japan liquefied natural gas regulations

In Japan, the governing agency involved in LNG terminal siting and operation is the Ministry of Economy, Trade and Industry (METI), which administers the Gas Utility Industry Law, the Electricity Utility Industry Law and the High Pressure Gas Regulation Law. LNG terminal siting and operation must comply with the following guidelines under the Gas Utility Industry Law. First, gas utility companies should maintain a gas facility in accordance with an adopted technical standard. Second, operators must define, submit and monitor the operator's own security regulations to ensure the safety of construction, maintenance, and operation of gas facilities. Third, allocation of a gas-licensed engineer to certify the safety of construction, maintenance and operation of a gas infrastructure (GIIGNL, 2014d).

Although Japan is no longer the number one destination of NLNG cargo since 2015 due to development at and proximity with Australia, Japan remains the number one importer of global LNG, importing 83.34 Mt and 83.52 in 2016 and 2017 respectively. Japan LNG imports are higher than any country exports, which shows the relevance of Japan in the LNG market. Every major participant exports some of its cargo to Japan; as such it is necessary to make conscious efforts to satisfy Japanese laws to remain competitive in the industry.

Regulation is not a value chain in LNG distribution systems, however, the LNG sector is highly regulated, and there is one or more regulation guiding each and every supply and distribution system (Figure 2.7) in LNG supply chains. These regulations include production regulations such as installation and maintenance standards and health, safety, security and environment (HSSE); Shipping regulations such as home state, flag states and international waters regulations; tax laws; and contracts. Adherence to these regulations significantly influences SCFP in LNG distribution systems.

2.7 Summary of chapter two

To achieve research objectives one and two, relevant SCM and LNG supply chain related publications were reviewed. The review facilitated the identification of major NLNG distribution networks and their characteristics. NLNG supply chain systems consist of a series of networks that add value at every chain level from source to delivery of LNG to consumers. These networks consist of upstream which comprise of natural gas extraction and feedgas supply; midstream which consist of gas treatment, liquefaction, storage, and shipping; and downstream which comprise of regasification and distribution. NLNG has mainly control of the midstream supply chains.

In addition, literature analysis revealed that the objective of feedgas supply in NLNG distribution systems is steady usage without any interruptions. However, this objective is challenged by the security situation in the region. Further analysis established that the goal of a liquefaction plant is to maximise utilisation without interruption. NLNG has almost achieved this objective because as at the end of 2017 with 92% capacity utilisation in its LNG trains. Analysis also showed that the objective of the shipping network is that it should never require the NLNG liquefaction plant to reduce production to maximise profits. NLNG supply chain participants have channelled a significant portion of their investment into vessel capacity. Nigeria LNG has acquired six newer and larger capacity vessels between 2015 and 2016. This revealed that the NLNG distribution network has adequate vessel capacity relative to current production levels.

Although SCM has been utilised by organisations to enhance financial performance, and efficient supply chain processes have been identified as key drivers for successful LNG networks, there has been a significant shortage of empirical studies on LNG supply chains and the energy industry's supply chains at large. This is quite evident in that industry data had to be reviewed in this chapter to facilitate a coherent understanding. Moreover, the industry literature review failed to establish an explicit theoretical framework or a taxonomy of SCFP in LNG systems. The domain of LNG supply chain requires more research and this study aims to make contribution in that direction. The next chapter reviews and analyses relevant literature and theoretical underpinning for SCFP.

Chapter three: Theoretical framework of supply chain finance performance

3.1 Chapter three overview

There has been a significant shortage of empirical studies on LNG supply chains and extant literature has failed to establish an explicit theoretical construct or an updated taxonomy of SCFP in LNG systems or the energy industry's supply chains at large. This chapter systematically analyses relevant SCFP literature in study phase one, to synthesise strategic drivers, capabilities and measures of SCFP (Objective 3).

The study analyses how SCM capabilities that drive financial performance evolved and proposes an updated generic taxonomy and framework of SCFP, which will be validated and measured empirically in subsequent chapters. Key word searches identified candidate publications between 1999 and 2018. Qualitative template analysis of texts identified SCFP drivers and measurement criteria. SCM capabilities were identified as initial coding templates and later modified using data from other articles to generate a generic taxonomy and conceptual framework of SCFP.

3.2 Supply chain finance

Following the 2008 economic downturn, substantial reductions in issuance debt and increased financial costs have restricted corporate liquidity (Ivashina and Scharfstein, 2010). Subsequent solutions and programmes to optimise financial flow have embraced SCF (Caniato *et al.*, 2016). SCF is a set of technology-based business (Lamoureux and Evans, 2011) or financial institution solutions (Chen and Hu, 2011) that link the various parties in a transaction together to reduce financing costs and to improve business efficiency. SCF provides short-term credit that optimises working capital for both the buyer and the seller. SCF utilises the strengths of supply chain links to optimise working capital and provide liquidity to businesses (Caniato *et al.*, 2016). SCF enables suppliers to sell their invoices or receivables at a discount to banks or other financial service providers. In return, the suppliers gain quicker access to funds, enabling them to use it for working capital, while buyers generally have more time to pay.

Debates have established two major perspectives regarding SCF. First, the "finance oriented" perspective, which focuses on short-term solutions provided by financial institutions to address accounts payable and receivable. Second, the "supply chain oriented" perspective, which might not involve a financial institution, and is focused on working capital optimisation in terms of accounts payable, receivable, inventories, and sometimes fixed asset financing (Gelsomino *et al.,* 2016). However, both finance oriented and supply chain oriented perspectives of SCF are targeted towards working capital optimisation. SCF ties financial transactions to value as it moves through the supply chain, and encourages integration and collaboration between the buyer and seller, rather than the competition that often pits buyer against the seller (Caniato *et al.*, 2016). The SCF arrangement often results in an increase in trust, commitment and profitability through the chain (Randall and Farris, 2009).

The link between SCM and corporate financial performance is increasing (Martin and Patterson, 2009). Business networks including NLNG supply chains are constantly pursuing strategies to enhance their supply chain performance to reduce costs and downtime, to improve their productivity and customer base, and to become more sustainable. As executives realise that supply chain competition has now supplanted corporate competition, a well-managed supply chain offers a gestalt in which the value of the whole exceeds the sum of its parts. Supply chain finance supports the financial flow which enables network participants to improve working capital and to reduce costs (Zhong, *el al*., 2018; Wutke *et al.,* 2013b). Indeed, any supply chain management strategy should ultimately aim to optimise SCF (Shi and Yu, 2013). This study aims to identify key SCM initiatives that drive financial performance to devise a framework for SCFP to guide NLNG supply chain participants and researchers in the design and implementation of supply chain strategies that enhance financial performance.

3.3 Supply chain financial performance

The nexus between SCM and corporate financial performance is increasing (Martin and Patterson, 2009). Supply chain practices are increasingly complex and strategically important in creating and maintaining firms' competitive advantage (Ellinger and Ellinger, 2014). Modern supply chain design generates a major source of competitive advantage for companies (Okongwu *et al.*, 2015), and supply chain practice impacts financial performance positively (Greer and Theuri, 2012; Johnson and Templar, 2011; Robb *et al.,* 2008). Firms now realise the strategic significance of SCM and appreciate the unique competitive advantages that a well-managed supply chain brings (Stevens and Johnson, 2016; Shi and Yu, 2013; Liao *et al.* 2011; Green Jr, *et al.,* 2008). SCM assists in creating or destroying shareholder value due to its influence on financial results (Ellinger *et al.*, 2011). Managers need to identify supply chain initiatives that create the most value for shareholders (Losbichler *et al.* 2008). Recently, SCM has attracted considerable investment (Ellinger and Ellinger, 2014) which managers must justify and demonstrate how such investment boosts financial performance (Shi and Yu, 2013). This need for enterprise efficiency is compelling executives to identify, review and adopt supply chain strategies that drive corporate financial performance.

To date there is only one prior statement that presented a combination of SCM competencies that drive financial performance, which consist of *sourcing strategy, technology, system integration and external relationships*, measured by *revenue, cost and working capital* (Shi and Yu, 2013). All other qualifying articles study the relationship between supply chain strategy and financial performance using disjointed drivers such as integration and information sharing or human resource or technology. Other publications presented only the supply chain measuring criteria without showing combinations of the supply chain capabilities that drives financial performance (Cristopher, 1998; Christopher and Ryals, 1999). In study phase one, template analysis (Brooks *et al.,* 2015) was deployed to analyse existing literature spanning 1999 to 2018 to identify key drivers and sub-drivers that enhance financial results, to devise an updated explicit taxonomy of SCFP to guide practitioners and researchers in the design and implementation of supply chain strategies. Template analysis procedure entails developing an initial coding template based on a subset of data (Figure 3.1; Appendix 1), which is subsequently revised and refined as further data emerge to form the final template (Figure 3.2; appendix 2) (Brooks *et al*., 2015).

3.4 Study phase one: Template analysis of SCFP literature

In this section of the analysis, extensive literature texts relevant to SCFP strategies were analysed systematically using template analysis to develop a generic framework and a taxonomy of SCFP.

3.4.1 Initial theoretical template for SCFP

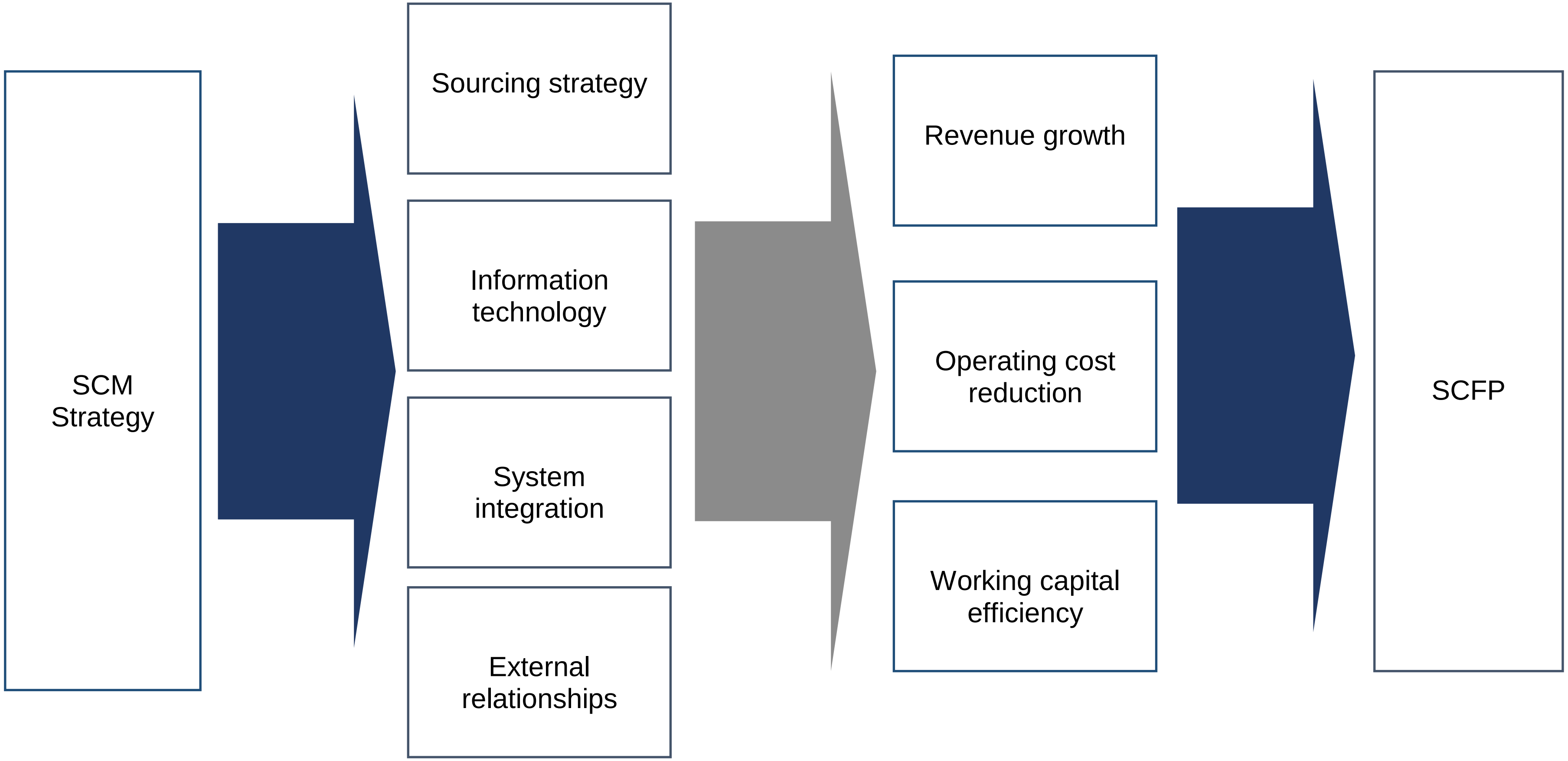
Higher-order themes for the initial template were derived from the only qualifying article (Shi and Yu, 2013) which explicitly stated SCFP drivers alongside financial performance measures. Themes for SCM practices included *sourcing strategy*, *information technology, system integration and external relationships*, and *revenue growth, cost reduction and working capital efficiency* as financial performance measures (Table 3.1; Figure 3.1; Appendix 1). Shi and Yu's (2013) interpretation of SCFP strategy was employed to analyse texts to build an explicit taxonomy and framework.

Table 3. 1: Higher-order SCFP themes for initial coding template

Drivers	Measures
Sourcing strategy	Revenue growth
Information technology	Cost reduction
System integration	Working capital efficiency
External relationship	

Source: Adapted from Shi and Yu (2013)

Figure 3. 1: Initial theoretical framework for supply chain financial performance



Source: Adapted from Shi and Yu (2013)

3.4.2 Final empirical template for SCFP in NLNG systems

After identifying a base definition from the initial theoretical template, further data items from qualifying literature extracts were applied to develop the final theoretical template (Appendix 2). Iteratively modifications were applied where weaknesses appeared relating to how well data was captured, relevant and potentially important (King and Brooks, 2017) (Section 4.4.2). The final template for SCFP drivers introduced new themes and modified a majority of the themes. *Sourcing strategy* and *information technology* remain much as in the initial template, but *integration and collaboration* combine both system integration and external relationships. *Sustainability* is a new higher-order theme which develops as further data emerges (Table 3.2).

Table 3. 2: Comparison between initial and final theoretical templates

Higher-order themes for initial template	Higher-order themes for final template
Sourcing strategy	Sourcing strategy
Information technology	Information technology and automation
System integration	Integration and collaboration
External relationship	Sustainability

Source: Author

In the final template, *revenue growth, cost minimisation and working capital efficiency* remained as the higher-order measurement criteria for SCFP. However, *assets utilisation* emerged as an additional higher-order measure, taking into consideration all the four components of economic value-added (EVA) (Appendix 2).

3.5 Discussion of key theoretical findings

The final theoretical template (Appendix 2) identified *sourcing strategy, IT and automation, integration and collaboration and sustainability* as higher-order themes that drive SCFP in supply chain networks. *Sourcing strategy, IT and automation, integration and collaboration and sustainability* remain similar to Shi and Yu's (2013). However, the term *sustainability* emerges from remaining data set. The emergence of *sustainability* as a key theme for SCFP was not surprising due to the influences of social and environmental practices to SCFP. Due to increasing social and environmental awareness, *sustainability* is synonymous with business survival growth.

3.5.1 Sourcing strategy as a driver of SCFP

Template analysis established *sourcing strategy* as a higher-order supply chain capability. As proposed by TCE, *efficient sourcing strategy should enhance financial performance*. *Sourcing strategy allows supply chains to focus on key competitive advantages* that result in win-win situations for all participants (Shi and Yi, 2013). There are *strong links between strategic purchasing and supply management, customer responsiveness, and financial performance* including ROI, profit margin, and average net income before tax (Chen *et al.,* 2004). A purchasing function's ability to advance exploratory activities enhances supplier efficiency, supplier product innovation, and buyer financial performance (Gualandris *et al*., 2018). Supplier innovativeness directly improves manufacturer innovativeness and indirectly enhances financial performance (Li, *et al*., 2018).

Outsourcing and subcontracting-in with non-supply chain partners are positively related to operational innovation, and operational innovation fully mediates the *influence that subcontracting-in has on financial performance and partially mediates the influence of outsourcing on financial performance* (Oke and Kach, 2012). Extant studies identified conflicting findings regarding the influence of *sourcing strategy*. Outsourcing can produce positive, negative, mixed, moderated or no significant impact on performance (Lahiri, 2016). *Financial productivity differs, depending on a sourcing decision between offshore and re-shore sourcing*. The re-shoring sourcing through domestic production strategy can lead to better profitability, including gross margin return on inventory with service level (Yu and Kim, 2018). Outsourcing strategy should be based on a careful analysis of the demand/supply characteristics of the various product/markets (Christopher *et al.,* 2006). Optimum supply chain strategy considers product characteristics, demand characteristics and replenishment lead-time (Christopher and Towill, 2002). *To improve financial performance, the costs of implementing a certain sourcing strategy should not outweigh its benefits*. Within strategic purchasing and supply management, *sourcing strategy is concerned with how supply chains constantly evaluate the costs of make-or-buy decisions* (Shi and Yu, 2013).

Although traditionally studies employed TCE to analyse the relationship between sourcing and performance, Espino-Rodríguez and Padrón-Robaina (2006) utilised a more strategic resource-based view (RVB) to establish the relationship between outsourcing decision and organisational performance. *Sourcing strategy* embraces some supply chain operating reference (SCOR) model constructs whereby collectively, some plan and source/buying decisions are more important to customer-facing supply chain quality performance such as reliability, response, and flexibility (Li *et al.,* 2011). Flexibility and reliability of the suppliers and regions are significant in developing contingency plans for disruptions (Kamalahmadia and Mellat-Parast, 2016). There are *strong associations between sourcing* *flexibility, delivery performance, and product financial* performance underscore that sourcing flexibility requires the attention of supply chain managers during supplier selection and purchasing decisions (Wagner *et al.,* 2018). Conversely, *decisions to make positively affect internal performance metrics concerning costs and assets*. Supplier collaboration and integration is integral to *sourcing strategy* because it facilitates reliable delivery (Lee *et al.,* 2007). Cross-functional integration and functional coordination enhance purchasing performance and *purchasing performance positively impacts firm financial performance* (Foerstl *et al*., 2013). However, neither purchasing maturity nor purchasing strategic alignment are suitable approaches to respond to disruptive technologies (Søgaard *et al.,* 2018). Strategic sourcing can stimulate sustainable competitive advantage by enabling companies to develop close working relationships with suppliers, to promote information sharing, and to build long-term strategic relationships to achieve mutual benefits (Chen *et al.,* 2004). Delivery system, products quality, supply, customer's order and legal/political regulations are the most important risk drivers in petroleum systems (Tarei *et al.,* 2018). Kauppi *et al.,* (2018) established that sourcing in and from Africa should consider African culture and ethics; the role of African countries and suppliers in global value chains; an increasing emphasis on sustainability; and the gradual development of professional procurement practices. Similarly, Thornton *et al.* (2013) reported increased financial performance amongst firms that consider CSR aspects during the supplier selection process, but results may differ in developing nations.

The foregoing discussion confirmed *sourcing strategy* as a key driver towards building a theoretical framework for SCFP. Further analysis established other factors that impact *sourcing strategy* as a driver for SCFP. The factors influencing *sourcing strategy* include strategies for *constantly weighing the costs associated* *with make-or-buy decisions; cost of carrying out economic (TCE); purchasing and supply management decision;* and *outsourcing and contracting-in* (Section 3.6; Appendix 2).

Proposition one: *Supply chain "sourcing strategy" is vital to a SCFP framework. "Sourcing strategy" is more efficient when there is collaboration and integration with suppliers. "Sourcing strategy" is also influenced by cross-functional integration and functional coordination, as well as flexibility and reliability of suppliers. However, to sustain the financial benefits, participants must constantly weigh the costs of a make-or-buy decision.*

3.5.2 Information technology and automation as a driver of SCFP

The final theoretical template (Appendix 2) depicts *IT and automation* as a higher-order supply chain theme. *Technology-based networks make positive contributions to financial performance* (Dehning *et al.,* 2007; Webster, 2002). *Financial performance from supply chain technology investments are derived from improvements in knowledge-intensive capabilities*, which result in improved operational capabilities, leading to inventory efficiency, improved logistics, *sales growth, costs minimisation*, and increase in return on equity (ROE), return on assets (ROA) and return on investment and profit margin. However, the performance influences of supply chain technology and automation capabilities reveal scepticism that *certain technologies can be imitated by competitors which may erode the competitive advantages of investment* (Shi and Yu, 2013), *and the ability to realise financial benefits are influenced by a company's position within the system and exogenous economic forces* (Blankley, 2008). *Managing the firm's levels of network power and cohesion increase financial results* (Carnovale *et al*., 2018).

A data-driven supply chain has a significant positive influence on coordination and network responsiveness, which are associated with financial results (Yu *et al.,* 2017). There is *a direct positive relationship between technology integration and supply chain integration, which is an enabler for customer service, in turn directly influences financial performance* (Vickery *et al.,* 2003). Availability of technology such as *electronic ordering systems for customers is an important strategy in cost-containment* (Lee *et al.,* 2007). Implementation of an electronic system results in improved accuracy of information, security, speed and *cost* in international networks. Information technology improves trust by minimising concerns for secure data with legal integrity (Mei and Dinwoodie, 2005). Evolving integration of just-in-time driven processes including *point-of-use systems, assemble-to-order systems, elimination of physical inventory counts, and an online supplier program, were linked to improved processes such as physical plan layout and use, material handling, quality control and manufacturing efficiency, thereby improving financial outcome* (Mistry, 2005). *Big data-driven networks enhance financial performance* (Govindan *et al.,* 2018). Data-driven networks have a significant positive effect on supply chain capabilities. *Coordination and network responsiveness improve financial results significantly* (Yu *et al.,* 2018). Technology systems is the primary co-ordination device for the reduction and absorption of complexity in the retail chain (Bourlakis and Bourlakis, 2005). Retail multinational companies possess greater operational efficiency compared to domestic firms due to high levels of logistics integration and IT operations. *Multinational companies' superior operational efficiency is linked to higher profitability* (Bourlakis and Bourlakis, 2006).

There is a strong relationship between market volatility, technology and financial performance. *As environmental unpredictability increases, e-commerce that* *integrates a firm with network partners has less effect on operational and financial performance*. Conversely, *increasing environmental unpredictability magnifies the effect of network analytic IT that fosters operational and strategic decision-making on operational and financial performance* (Davis-Sramek *et al.,* 2010). Investments in supply chain technology such as *enterprise resource planning (ERP) can reduce the frequency and intensity of supply chain glitches, thereby improving financial performance, specifically in terms of ROA and return on sales (ROS)* (Hendricks and Singhal, 2005). Information system facilitates innovation; however, *innovation has associated costs* (Bunduchi and Smart, 2010). *Accumulation of technology, desire for innovation, quality of human resource, and government support has significantly influenced radio-frequency identification (RFID) adoption, in turn related to both financial and non-financial supply chain performance* (Lin and Ho, 2009). *Innovation improves revenue* generation through either higher prices or larger volumes (Edwards *et al.,* 2004). *Supply chain positively impacts financial results; however, this could be affected by technology alignments and implementations* (Shi and Yu, 2013). Different *e-collaboration tools at various value chains enhance both operational and financial outcomes of the entire system*. However, *focal firm financial constraints can severely affect the operational and financial performance of the entire network* (Marquez *et al.,* 2004).

Various theoretical stances are apparent in the qualifying papers. *According to TCE, technology and automation enhance supply chain collaboration and integration, and minimise administration and coordination costs* (Shi and Yu, 2013). From an RBV perspective both strategic relationship and technology internalisation positively impact external and internal information integration. The former improves service quality, and the latter operational efficiency; both are positively linked to financial performance (Huo *et al.,* 2016). The performance influences of supply chain *technology and automation* capabilities are debateable. Shi and Yu (2013) argue that according to RBV, increasing investments in technology capability do not guarantee performance improvements. Other factors influence *technology and automation* impacts on financial results. Combining a *RBV alongside contingency theory shows that e-business strongly impacts supply chain integration and integration strongly affects financial performance*, if companies are situated in countries with high quality regulatory levels (Wiengarten *et al.,* 2015). Kim *et al.* (2012) examined technology adoption in supply chain contexts between two national environments. Findings revealed varied outcomes due to differences in national industrial foundations, organisational network infrastructures, and perspectives on system development, as well as issues related to the *costs* and practical benefits of using technology in SCM. Wiengarten *et al.* (2013) applied a RBV and contingency theory and suggest that firms might be able to gain significant performance improvements if technology resources are in alignment with organisational strategy, process, culture and structure. Applying *the contingency theory "fit" concept shows a positive relationship between e-commerce supply chain integration and financial, market, and operational performance*, which decreases as product turbulence and demand unpredictability jointly, increase (Iyer *et al.,* 2009). Drawing on complementarity theory, Cheng and Krumwiede (2018) show that *social media use, market, and technological knowledge-processing capabilities enhance the effect of supplier involvement on new product development performance in terms of product innovativeness, market and financial performance*.

The preceding discussion confirmed *IT and automation* as a key driver to developing a theoretical framework for SCFP. In addition, findings revealed other factors that impact *IT and automation* as a key driver for SCFP. The factors influencing *IT and automation* include strategies for *investment in supply chain technology, implementation, alignment and integration; cost of carrying out economic (TCE); strategic resources with the potential to deliver competitive advantage (RBV);* and *(2.4) innovative solutions* (Section 3.6; Appendix 2).

Proposition two: *supply chain "IT and automation" is fundamental for a framework of SCFP. Integration and collaboration fosters technology adaptation and implementation. However, financial benefits could be affected by technology implementations, bargaining power and financial strengths of the leading company, market unpredictability, location, regulations and imitations by competitors.*

3.5.3 Integration and collaboration as a driver of SCFP

In the final empirical template (Appendix 2), *integration and collaboration* is the dominant theme in developing a SCFP taxonomy. An *integrated network increases a company's capability to coordinate all business processes to achieve financial benefits* (Beheshti *et al.,* 2014; Shi and Yu, 2013). *Supply chain integration and collaboration capabilities are associated with firm financial performance* (Stevens and Johnson, 2016). *Collaboration with non-supply chain partners as part of supply chain strategy is positively related to operational innovation, which partially mediates the influence of collaboration on financial performance* (Oke and Kach, 2012). Supply chain relationships is linked to innovation performance and productivity. The benefits of networking include risk sharing, access to new markets and technologies, speeding products to market, pooling skills, safeguarding property rights and access to external knowledge (Pittaway *et al.,* 2004). *Supply chain knowledge flow enablers, including integration and relational practices, enhance knowledge flow performance and financial performance* (Bhosale *et al.,* 2018; Kohtamäki and Bourlakis, 2012). Competitive strategies significantly influenced the effectiveness of integrative practices, including internal, process and product integration. Similarly, both *system and process integration improve financial results* (Huo *et al.,* 2013). Ou *et al.* (2010) found *a strong relationship between external relations and internal contextual factors, which in turn enhance operational and financial performance*. Both *internal or intra-firm and external or inter firm supply chain integration and collaboration impact SCFP* (Seo *et al.,* 2014).

Intra-firm integration involves linkages across divisions and units of an organisation, often strongly linked to financial performance. *Companies who practise SCM exhibit a strong relationship between internal integration and financial success* (Sriyogi, 2012). *Internal integration is the main contributor to cost minimisation* (Lee *et al.,* 2007). *Cross-functional integration and functional coordination impact purchasing performance positively and in turn, firm financial performance* (Foerstl *et al.,* 2013). Competitive strategies significantly influenced the effectiveness of integrative practices, including internal, process and product integration. *Internal integration* significantly affected the performance of *cost* leaders, and process integration contributed more to the performance of differentiators (Huo *et al.,* 2014). *Internal logistics integration activities facilitate particularly tacit knowledge capture, which impacts internal process improvement, investment and financial performance*, particularly in make-to-order firms (Birou *et al*., 2011). *Internal integration leads to external integration,* *including information flow integration that provides the basis for financial flow* and physical flow integration (Sacristán-Díaz *et al*., 2018).

Inter-firm integration comprised of supplier and customer integration is pertinent to a taxonomy of SCFP. Alliances with network partners facilitate information and knowledge-sharing, shared understanding and the pursuit of collective goals (Niesten and Jolink, 2015). Integration where the emphasis is on long-term and joint planning facilitates information sharing (Jraisat *et al*., 2013). *Extensive process integration and information sharing affect financial performance favourably for partners in terms of sales growth, sales productivity, and profitability*, and enhance the likelihood of distributor contract renewal (Schloetzer, 2012). Supplier integration enhances the impact of supply chain risk management on operational flexibility (Shou *et al.,* 2018). Cooperation and long-term commitment were correlated with supplier performance, but a high degree of coordination, information-sharing, and feedback were not (Field and Meile, 2008). *Focal firm financial dependence and supplier financial dependence directly affect firm financial results* (Elking *et al.,* 2017). *Implementation of collaborative planning, forecasting, and replenishment has a positive effect on a firm's financial and operational performance* as compared to similar firms who do not adopt the initiative (Hill *et al.,* 2018). There are positive *relationships between customer-focus and supply chain relational capabilities; customer focus and customer service; supply chain relational capabilities and customer service; and customer service and financial performance* (Lado *et al.,* 2011). *Mutual dependence with major customer networks enhances supplier financial performance in terms of ROA and ROS* (Kim, 2017). The implicit certification from long-term relationships with principal customers has reputational consequences that potentially spill over to other markets, as firms capable of retaining principal customers longer are perceived as safer firms by banks (Cen *et al.,* 2016). *Information sharing, quality of information, customer relationship and supplier partnership were associated with financial performance* (Okongwu *et al.,* 2015).

Involving financial service providers in the integrated management enhances SCF practices by matching network gaps with available service on offer (Martin and Hofmann, 2017). *Concentrated networks achieve superior financial performance*, and network financial result varies with measures of chain concentration and duration. Firm-level analyses suggest that the profitability benefits of supply chain relationships are captured predominantly by downstream chain members, whereas cash-to-cash (C2C) cycle benefits are realised throughout the network. Firm-level tests also indicate that chain members' financial performance varies with downstream bargaining power, relationship duration, and degree of supply consolidation (Lanier *et al.,* 2010). Retailers exercise various commercial practices (power-imbalanced dyadic relationship) with their suppliers, including dependence, financial goal incompatibility, informational asymmetry and behavioural uncertainty. These practices consist of upfront payments, unanticipated changes of agreements and negotiation pressures (Maglaras *et al.,* 2015). Firm debt level has a positive relationship with the degree of network concentration (Kalea and Shahrur, 2007). *Mutual trust is extremely important to manage external relationships; it influences integration and both supplier and customer integration improve financial outcomes* (Zhang and Huo, 2013). *Trust between small-and-medium enterprises and their suppliers has significant positive effect on SCFP*. This is beneficial for both parties in terms of *cost*, lead-time, inventory management and increased profit and customer satisfaction (Susanty *et al.,* 2018). Firms generate superior supplier performance if they retain internal technical skills as well as increase their use of external governance mechanisms to manage buyer-supplier relationships (Parmigiani and Mitchell, 2010).

How integral is *integration and collaboration* to a taxonomy of SCFP? Drawing on RBV and TCE, Zhao *et al.* (2015) found that *external and internal integration may both favourably and adversely impact financial results.* Drawing on a KBV, Gu *et al.,* (2017) suggest that *strengthened relationships with suppliers improve suppliers' operational performance, which will positively influence manufacturers' operational performance directly, and financial performance indirectly*. Combining an environment-strategy-performance view and relational view, Srivastava *et al.,* (2017) analyse how a proactive partnership strategy response to co-align with its contextual determinants, results in better performance and how resource complementarity and resource specificity facilitate collaborative, operational and financial performance. *Internal integration significantly influences both customer and supplier integration, in turn positively related to financial performance*. Consistent with organisational learning theory, *internal integration* is an enabler for *external integration* (Yu *et al.,* 2013). From an organisational information processing theory perspective, the degree to which supply chain information integration positively impacts business performance depends on the level of product and market complexity, with greater impacts when it serves less complex products or is operated under a highly complex market environment (Wong *et al.,* 2015). Chang *et al.* (2016) apply positional advantage theory and a RBV to examine how internal, *supplier and customer integration enhance firm financial performance*. Results uphold that each dimension of *integration* improves financial performance. Drawing on TCE and agency theory, Sumo *et al.* (2016) propose how performance contracts foster innovation in inter-organizational relationships.

Ralston *et al.'s* (2015) structure-conduct-performance perspective established that *aligning internal and external integration strategies with customers and suppliers affects a firm's ability to respond to customer demand, which impacts operational and financial performance*. Drawing on resource dependency theory, Kim and Henderson (2015) found that *supplier and customer dependency both increase the focal firm's performance in terms of ROA and ROS by increasing asset turnover*. However, as levels of supplier and customer dependency on the focal firm increase, the economic benefits of customer dependency diminish beyond a certain point, while those of supplier dependency continue to increase. Liao *et al.* (2011) drew on contingency theory, Porter's economic cluster theory and international factory mapping to show that an automotive global supply chain adaptation includes market entry considerations, the establishment of a *three-stage flexible time and production-based supplier network plan, and the integration of logistics partners which improves financial results*. Drawing upon contingency theory, Iyer *et al.* (2009) established the *impact of business-to-business integration on financial, market, and operational performance*. However, this impact decreased as product turbulence and demand unpredictability jointly increased. Insights from RBV and contingency theory indicate that *e-business strongly affects integration and that integration strongly impact financial performance, when firms are in countries with high quality regulations* (Wiengarten *et al.,* 2015).

Banks enable integration by supporting buyers and suppliers with coordination, collaboration, information sharing and information visibility (Silvestro and Lustrato, 2014). Technology is a known enabler of integration. Technology infrastructure significantly impacts *integration* and performance (Agan, 2011). *E-collaboration tools at different levels of integration enhance network operational* *and financial outcomes* (Marquez *et al.,* 2004). Supply chain relationships and technology are established amongst key SCFP criteria (Webster, 2002). Strategic network relationship and supply chain technology internalisation impact external and internal information integration positively. The latter is positively linked to service quality, and the former to operational efficiency, in turn impacting financial outcome positively (Huo *et al.,* 2016). However, implementation of business models becomes more complex when it is proposed by or requires a network of collaborating enterprises. Careful consideration of business model operational components from a network perspective facilitates value creation (*Solaimani et al*., 2018).

Uncertainties impact *integration* and financial performance. *Increased environmental unpredictability weakens the effect of business-to-business e-commerce that integrates a firm with network members on operational and financial performance*. In contrast, *increasing environmental unpredictability strengthens the effect of supply chain analytic that fosters operational and strategic decision-making on operational and financial performance* (Davis-Sramek *et al.,* 2010). In a predictable demand environment, only formal control affects supply chain process variability, leading to improved financial results but in an unpredictable demand environment, only cross-functional *integration* affects supply chain process variability, leading to improved financial outcome. *Integration* enhances flexibility which helps in addressing uncertainties and glitches (Germain *et al.,* 2008). Demand uncertainty is associated with greater lead-time variance and production technology routineness is linked to lower lead-time variance (Polo *et al.,* 2018; Christensen *et al.,* 2007). *Collaborative transport management significantly minimises cost and enhances flexibility, especially under a demand disruption environment* (Li and Chan, 2012).

Collaboration minimises travel time and enhances speed of delivery, which in turn improve sustainable supply chains to reduce economic, environmental and social costs (Zissis *et al*., 2018). Collaborative networks are not only more profitable but also more robust to variations in lead-times (Ponte *et al.,* 2018). To address uncertainty issues, Li *et al.* (2017) reveal that *supply chain resilience, preparedness, alertness and agility, significantly impact a firm's financial results*. Similarly, agility, adaptability, and alignment (triple A) strategies positively impact SCFP. *All Triple A variables of agility, adaptability and alignment have positive impacts on flexibility and financial competitive advantage* (Alfalla-Luque *et al.,* 2018). Firms can deal with network volatility, the ensuing risk and mitigate the *cost* influences. Static low unit *cost* seems no longer fitting under conditions of persistent volatility, and that volatility should be embraced as a factor in supply chain design, rather than seeking to eliminate it in supply chains (Christopher and Holweg, 2017).

Although supply chain performance is more strongly related to marketing performance than financial performance, marketing performance positively impacts financial results (Whitten *et al.,* 2012). Technology facilitates lean and agile supply chain strategies. Firms with a strategy focused on lean, agile, or lean/agile strategy perform better than those with a traditional strategy (Qi *et al.,* 2009). Supply chains need to address the issue of relationship integration when developing agility and flexibility programmes to maximise performance (Fayezi, *et al.,* 2017). Real-options is a SCF practice that explores opportunities to use supply chain variability as a strategic tool that makes up for supply chain flexibility (Avanzi *et al.,* 2013).

The foregoing discussion confirmed *integration and collaboration* as the major driver towards building a theoretical framework for SCFP. Further analysis established other factors that impact *integration and collaboration* as a driver for SCFP. The factors influencing *integration and collaboration* include *intra-firm integration and integrated supply chain system; inter-firm collaboration and integrated partnership; flexibility;* and *integration with information technology infrastructure* (Section 3.6; Appendix 2).

Proposition three: "*Integration and collaboration" is integral to a taxonomy of SCFP. Integration and collaboration fosters supply chain flexibility strategy which improves financial benefits especially during market unpredictability. However, the performance of "integration and collaboration" could be affected by the level of trade digitalisation, concentration and duration of the supply chain, product and market complexities, bargaining power, and mutual trust.*

3.5.4 Sustainability as a driver of SCFP

In the final theoretical template (Appendix 2), *sustainability* is a higher-order supply chain capability. *Sustainability* in competitive global networks extends beyond Brundtland's definition of sustainable development that *"…meets the needs of the present without compromising the ability of future generations to meet their own needs"* (United Nations, 1987). Supply chain *sustainability* now includes business survival in a risky and competitive environment, pursuing social and environmental performance, while simultaneously aiming for financial benefits. The concepts SCM and *sustainability* aligned due to their explicit interactions (Ashby *et al.,* 2012). Increasing interest in *sustainability reflects concerns with climate change and ecosystems which necessitate environmentally friendly practices as a competitive supply chain strategy for* *financial performance* (Mura, *et al*., 2018; Bastas and Liyanage, 2018; Ntabe *et al.,* 2015; Srivastava, 2007).

To maximise the positive financial benefits of *sustainable practices*, all network participants should jointly engage in sustainable operations. Integrated *sustainable practices, including social and environmental practices are positively associated with corporate financial performance measured by ROA and ROE*. Joint implementation of both *social and environmental supply chain practices significantly affects financial performance* (Zissis *et al*., 2018; Wang and Sarkis, 2013). CSR in shipping networks covers a wide range of issues, Non-compliance with *sustainability practices* can lead to major accidents in a more skilled sectors. *Accidents may cause huge environmental damage and loss of life, and may incur substantial fines and financial penalties that will erode financial performance* (Sampson and Tang, 2016).

CSR has evolved into supply chain responsibility (Spence and Bourlakis, 2009). Manufacturing companies adopting environmental and social strategies enhanced their competitive advantage which lead to long-term sourcing relationships for the buyer-supplier relationships (Ghadimi *et al.,* 2017). The financial performance of firms that consider CSR during the supplier selection process outperforms competitors (Thornton *et al.,* 2013). *Supplier development and proactive defective or unsafe product recall significantly contribute to quality and financial performance* (Tse *et al.,* 2018). An analysis of CSR in container shipping reveals that while institutional pressure plays an important role, companies are more sensitive to customer expectations, including environmental concerns, occupational health and safety, local community welfare and workers' rights and welfare (Tang and Geraka, 2018). It is established that pressure to squeeze more effort out of shipping seafarers in the oil shipping industry occasionally leads to the seafarers using supply chain leverage to their advantage by tactically exposing defects during ship inspections (Tang and Bhattacharya, 2018).

Sustainable SCFP has a bidirectional relationship with companies' margins and revenue but the link between firms' profitability and sustainable SCFP is unidirectional and the 2008 financial crisis altered this link (Ortas *et al.,* (2014). These relationship patterns varied between geographical regions and economic sectors (Ortas *et al.*, 2014). *Internal environmental practices are a key driver of financial performance, and external practices are secondary* (Miroshnychenko *et al.,* 2017). Inclusive environmental disclosure practices influence financial performance but did not impact environmental performance (Longoni and Cagliano, 2018). *There is a strong relationship between SCR performance and SCFP* (Wood, 2010). *Green service outsourcing price is interrelated with the government incentive policy which enhances supply chain profits* (Ding *et al.,* 2018).

Developing supplier capabilities to deal with sustainability related issues improves economic and social performance (Yawar and Seuring, 2018). Linking CSR and SCM allows the exploration of strategies and performance outcomes with a focus on social issues (Yawar and Seuring, 2017). CSR performance is negatively related to the risk of corporate corruption (Lopatta *et al.,* 2017). *Negative workplace safety announcements decrease shareholder value* (Kabir, *et al.,* 2018). *However, the positive effect of CSR on financial performance depends on the levels of product differentiation and external investment* (Lee and Jung, 2016).

The above discussion inveterate *sustainability* as a key driver to developing a theoretical framework for SCFP. Further, results revealed other factors that impact *sustainability* as a key driver for SCFP. The Factors influencing *sustainability* consist of the all the triple-bottom variables of social, environmental and economic dimensions. In addition, the triple-bottom line variables are driven by other factors, including strategies for CSR; internal policy concerns; ecosystem; reputation; ISO 14001; optimum usage of material, energy/water and eco-efficient solutions; joint implementation of social and environmental strategies (Section 3.6; Appendix 2).

Proposition four: "*Sustainable" supply chain strategy is a component of a taxonomy of SCFP. Social and environmental sustainable supply chain practices have positive effects on the economic dimension of sustainable network, which is strongly linked to financial performance. Whilst the sustainable supply chain has a two-way positive relationship with margins and revenue, its link to profitability is one-directional. "Sustainability" in supply chains is more efficient when implemented jointly by all participants. The financial benefits of sustainable networks hence vary between regions, industries and products. Additionally, economic challenges such as a financial crunch could affect sustainable SCFP.*

3.6 Supply chain financial performance measures

Considering the importance of SCM strategies and competencies to business survival and growth, performance measurement is essential in evaluating the efficiency of SCF practices. Supply chain strategies and investments are linked to shareholder value (Gomm, 2010; Christopher and Ryals, 1999). In study phase one, template analysis explores SCFP measurement metrics to propose a taxonomy of SCFP. A taxonomy of SCFP comprises key financial performance measures, *revenue, costs, and working capital*. These are employed as higher-order themes in the initial theoretical template (Appendix 1). In the final theoretical template (Appendix 2) *assets utilisation* is an additional measure for financial performance, and also a component of EVA. *Assets utilisation is a major medium-term strategy for increasing shareholders value* (Hahn and Kuhn, 2012). *Whilst cost reduction remains a major objective of supply chain initiatives, companies view SCM* as a strategy to increase shareholders value and enhance competitive advantages (Christopher, *et al*., 2011; Losbichler *et al.,* 2008; Christopher and Ryals, 1999).

3.6.1 Analysis of supply chain financial performance measures

Through continual vigilance and adjusting to changing market conditions, leading supply chain firms outperformed the industry average in compound average growth rate of market capitalisation (Shi and Yu, 2013). Christopher (2011) reveals *revenue, cost, fixed capital, working capital and tax as five key drivers of shareholder value*. All five financial measures are directly and indirectly affected by supply chain strategy. The final theoretical template established all these items as higher-order financial performance measures, except tax. Tax and tariffs regimes differ between countries and location decisions can have an important impact on after-tax free cash flow. Supply chain decisions affect the total tax bill and shareholder value significantly. However, the final template (Appendix 2) indicates tax minimisation as a theme under *cost minimisation*, and not a higher-order theme.

Payment delays increases working capital and decrease total operational cost (Protopappa-Sieke and Seifert 2010; Zhong, *el al*., 2018). Drawing on TCE, managerial insights revealed that *managers can improve upstream working capital with pre-shipment SCF management, whereas post-shipment strengthens downstream working capital position* (Wuttke, *et al.,* 2013a). SCF can improve network performance by facilitating longer payment terms for buyers and better access to financing for suppliers (Wuttke *et al.,* 2016). A supplier fully coordinates the network for the largest joint profits through trade-credit in addition to coordinating contracts (Lee and Rhee, 2010). *Reverse factoring offers a working capital financing solution, initiated by the ordering parties to support their suppliers secure financing of receivables at favourable terms* (Lekkakos and Serrano, 2016). *Trade credit is a more effective SCF option than bank credit when production costs are relatively low, and bank credit becomes more effective otherwise*. Under trade financing, the upstream participant shares the risk of low demand with the downstream participant, who stocks more inventory (Jing and Seidmann, 2014).

Efficient supply chain strategy impacts company value (Brandenburg, 2016). Linking supply chain processes' performance to corporate strategic objectives enables companies to formulate strategies to enhance financial performance (Elgazzar *et al.,* 2012). A case study of an electronic manufacturing company by Mistry (2005) shows how adoption of *JIT leads to improved supply chain processes, and consequently enhances financial performance, measured by ROA components.*

Internal integration affects profits by driving process efficiencies, especially selling, general and administrative costs for firms that have broad process spans (Swink and Schoenherr, 2015). Dehning *et al.* (2007) examined the change in financial performance before and after supply chain technology adoption controlling for industry median changes in performance. They showed that *technology-based systems increase gross margin, inventory turnover, market share, ROS, and reduce expenses.* Further, *Technology-based supply chain investments result in sales growth, cost of goods sold reduction, selling, general and administrative reduction and improved ROE, ROI, ROA, and profit margins* (Blankley, 2008). *A major supply chain challenge is for firms to manage costly inventories, reduce cost and improve operating performance*. A multinational corporation's sales penetration into emerging markets is associated with less inventory and financial performance in terms of ROA and ROS (Han *et al.*, 2013). *Inventory and C2C cycle time are most useful for measuring the performance of supply chain companies* (Martin and Patterson, 2009). Collaborative financial management techniques such as *C2C positively impact supply chain profitability and performance* (Randall and Farris, 2009). Although *certain supply chain companies and industries were able to minimise their C2C cycle times, the general improvements were marginal* (Losbichler *et al.,* 2008).

Ellinger *et al.* (2011) used Z-score modelling as a compressive measure of firm financial wellbeing based on liquidity, profitability, productivity, solvency and activity. *Companies recognised by industry experts for supply chain competency have significantly higher Z-scores than their competitors and industry averages*. Li *et al.,* (2011) adopted SCOR model to demonstrate how the objective of implementing quality standards such as ISO 9001 will help companies to develop and maintain supply chain processes. By integrating quality assurance measures in the supply chain process, results show that individually, each decision area has a positive impact on both quality performance and business performance (*cost and asset).* However, the SCOR model focuses on identifying areas of improvement that will facilitate *cost reductions* and improve *asset efficiency*, making the framework focused on operational efficiency rather than relationships. Its processes are grounded on operations strategy as this focuses on engaging partners from the logistics, production and purchasing functions in the supply chain processes of plan, source, make, deliver, and return, which limits the model scope (Elgazzar *et al*., 2012). The SCOR model advocates a set of SCFP indicators without providing guidance to managers on how to identify the supply chain initiatives that create the best shareholder value (Losbichler *et al.,* 2008).

Strategies such as process innovation generate costs in supply chains (Bunduchi and Smart, 2010). Manufacturing companies' supply chain strategy that consists of lean, agile, and lean/agile approaches perform better in terms of product characteristics, financial and operational performance (Qi *et al.,* 2009). Moreover, *lean/agile and lean strategy performed significantly better than agile strategy with respect to operating cost*. An analysis by Bourlakis *et al.* (2014) established the link between *sustainability* performance with key financial indicators in relation to efficiency, flexibility, responsiveness and product quality. Banomyong and Supatn (2011) developed an internal supply chain assessment tool, which shows *cost as a major financial performance driver*. *Sustainable SCM, encompassing social and environmental practices are positively associated with financial performance measured by ROA and ROE, and these positive effects can have a time lag*. *Time management, including lead-time facilitates cost efficiency in networks* (Wang and Sarkis, 2013). *Time is linked to cost in supply chains*, and combined analysis of time and *cost* provides a better view of supply chain performance, which can lead to well informed decision-making (Whicker *et al.,* 2009).

Network disruptions and glitches affect financial performance in terms of operating income, sales, total costs, and inventories, and firms do not improve for two years after such glitches (Hendricks and Singhal, 2005). *In an unpredictable demand environment, only cross-functional integration affects supply chain process variability, leading to improved financial performance in terms of return on investment and profitability* (Germain *et al.,* 2008). The potential for hold-up can restrict performance benefits available to partners from developing more extensive integrative practices. *Extensive process integration and information sharing have favourable financial influences for supply chain partners in terms of sales growth, sales productivity, and profitability, and enhance the likelihood of distributor contract renewal* (Schloetzer, 2012). *Integrated capacity management reduces lost sales* (Hahn and Kuhn, 2012). Christopher (2011) established the impact of SCM on ROI showing that *customer service and logistics efficiency have direct impacts on revenue and costs* as components of profit. *Performance management, invoicing, JIT, and asset development impact elements of capital employed including cash, net-receivables, inventory and fixed assets*. The foregoing discussion proposed components of *revenue growth, costs reduction, working capital efficiency and fixed asset utilisation* as financial performance measures for a taxonomy of SCFP (Appendix 2), and that supply chain glitches significantly affect financial performance adversely.

3.7 Taxonomy of supply chain financial performance

A supply chain comprises many value chains across different locations which aim to add value at every chain level to achieve financial and non-financial performance across the entire network. Because network participants are rarely in the same location and most interact and make decisions using communications technology, each supply chain partner has a mandate or strategy to make or implement decisions that have performance influences. Supply chain strategies are vital for business survival. The strategies are calculated, competitive, robust, costly and highly complex. Although strategy plays an increasingly important role in supply chain growth and survival, little is known regarding supply chain strategies that drive financial performance, its dynamics and effectiveness. Using template analysis, this study developed a taxonomy for SCFP deductively by extracting explicit constructs from literature. Related publications are retained to analyse the texts and avoid data elimination, and to prevent researcher bias. The typology defines financial drivers logically, for example, *sustainability* includes social and environmental factors, and business growth and survival. Template coding conventions (King and Brooks, 2017; Brooks *et al.* 2015) are retained to ensure consistency.

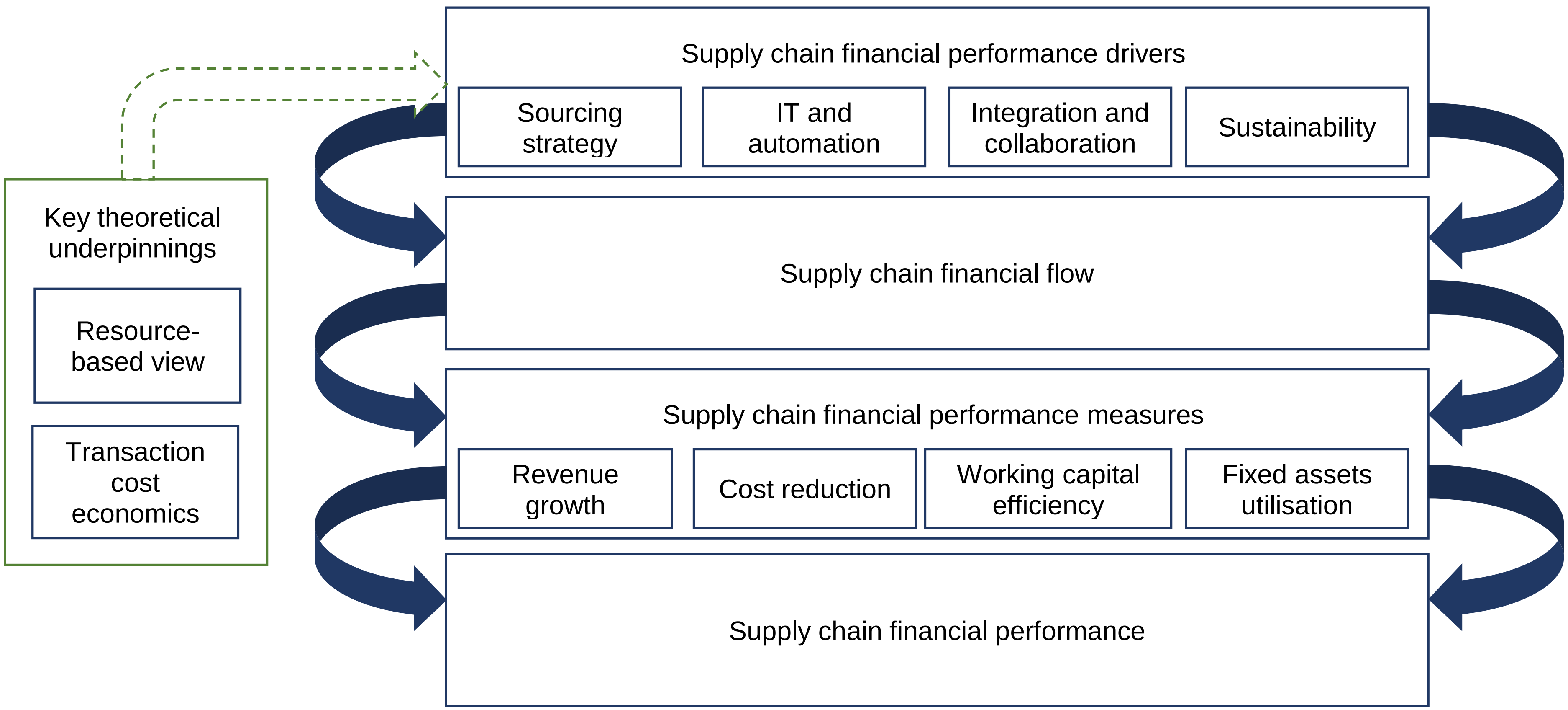
The final theoretical template (Appendix 2) defines the drivers of SCFP with higher-order themes and second-level themes encompassing (1) *sourcing strategy*, which involves (1.1) constantly weighing the costs associated with make-or-buy decisions, (1.2) transaction cost economics, (1.3) purchasing and supply management, and (1.4) outsourcing and contracting-in. (2) *Information technology and automation*, consists of (2.1) investment in supply chain technology, implementation, alignment and integration, (2.2) transaction cost economics, (2.3) resource-based view, and (2.4) innovative solutions. (3) *Integration and collaboration*, consists of (3.1) intra-firm integration and integrated supply chain system, (3.2) inter-firm collaboration and integrated partnership, (3.3) flexibility, and (3.4) integration with information technology infrastructure. (4) *Sustainable supply chain*, consists of (4.1) social dimensions, and (4.2) environmental dimensions.

SCFP is relatively difficult to measure as there are no established measurement criteria. As shown in Appendix 2, the theoretical template for financial performance measures incorporates conventional measures as surrogates for SCF measures. The template defines SCFP measurement themes which include (5) *revenue growth*, consisting of (5.1) increased shareholders value, which contains (5.1.1) profitability. (6) *Operating cost reduction*, comprises (6.1) increase shareholders value, which includes (6.1.1) profitability. (7) *Working capital efficiency*, includes (7.1) increase shareholders value, which consists of (7.1.1) increase shareholders value and (7.1.2) liquidity. (8) *Fixed asset utilisation* includes (8.1) medium term strategy of increasing shareholders value creation and (4.2) operating performance, which contains (8.2.1) net sales from fixed asset investments. These categories show the rationale behind SCFP, in case the taxonomy is incomplete, empowering supply chains to identify sub-categories and develop the typology. Further, the taxonomy provides an updated definition and proposes a conceptual framework for SCFP (Figure 3.2).

3.7.1 Supply chain financial performance defined

The theoretical taxonomy defines SCFP as the ability to optimise *sourcing strategy, information technology and automation, integration and collaboration, and sustainable* practices across supply chains, as well as the continuous interaction between these supply chain capabilities to realise full financial benefits of a SCM.

Figure 3. 2: Conceptual framework for supply chain financial performance



Source: Author

3.8 Theoretical underpinnings for supply chain financial performance

A theoretical framework offers a conceptual direction for choosing the concepts to be investigated and for framing research findings. A theoretical framework helps in determining the methodology to be used (Corbin and Straus, 2008). Study phase one established a gap in the existing SCM literature to connect theoretical background and empirical evidences. Although, some aspects of inter-firm connections are already present in numerous SCM studies, the field lacks a robust, comprehensive theoretical framework that covers the relationships between supply chain partners (Gelsomino *et al.*, 2016; Chelariu, *et al.,* 2014; Shi and Yu, 2013). The evidence that SCF lacks general theory is hardly surprising; SCF is a complex and relatively new notion. In addition, the division of SCF topic into diverse standpoints has led to the publication of disjointed ideas (Gelsomino *et al.*, 2016).

A limited number of studies have tried to lay theoretical backgrounds for SCM, employing several of organisational theories, including TCE (Williamson, 2008; Ketchen and Hult, 2007; Grover and Malhotra, 2003; Rindfleisch and Heide, 1997; Hobbs, 1996). Other researchers employed RVB (Spring, 2017; Vanpoucke, *et al.,* 2014; Gold *et al.* 2009; Seggie *et al.* 2006; Rai *et al.,* 2006; Zhu and Kraemer, 2002); agency theory, institutional theory, network theory, game theory, and strategic choice theory (Halldorsson *et al.,* 2007; Ketchen and Hult, 2007). However, analysis in study phase one revealed that with the exception of TCE and RBV, most theories do not received adequate empirical backings in SCF literature (Section 3.5; Figure 3.2). Thus, this study only reviewed TCE and RBV to establish the link between SCM practices and financial performance empirically, using NLNG supply chain networks as a case study.

According to TCE and RBV, effective SCM is expected to have positive impact on financial performance (Presutti and Mawhinney, 2007; Ellinger, *et al.,* 2011).

3.8.1 Transaction cost economics

"A transaction occurs when a good or service is transferred across a technologically separate interface" (Williamson, 1981: 552), which in NLNG networks is at every chain level from gas extraction to distribution to final consumer. The transaction cost approach to the study of economic entities regards the transaction as the basic unit of analysis and holds that an understanding of transaction cost economising is central to the study of organisations (Williamson, 1981). TCE was developed to examine the *costs* of carrying out any economic transaction (Shi and Yu, 2013); hence, it is a good fit for this study of LNG SCFP. The idea that transactions form the basis of economic thinking was introduced by the institutional economist Commons (1931), and TCE concepts were originally developed in the work of Coase (1937) and subsequently were broadened by Williamson (1975, 1981) as a phenomenon in social science. Ever since, TCE has gained enormous attention in several fields, such as marketing, management, law, finance and economics (Rindfleisch and Heide, 1997). *The main objective of TCE is to maximise firm performance by minimising transaction costs within and outside the boundaries of organisations* (Ketchen and Hult, 2007).

Shi and Yu (2013) argue that TCE provides a natural fit to SCM undertakings. First, *supply chain organisations often take "make-or-buy" decisions to minimise purchasing costs*. Second, *exchange of information between customers and suppliers is essential to reduce the coordination costs*. Third, *transaction risks may cause substantial operating costs to the supply chain as a whole*. Developing an effective instrument to mitigate coordination inefficiency is an important challenge in SCM. Hobbs (1996) suggests that *to reduce transaction costs throughout supply chains, co-operations, teamwork, and swift data exchange between supply chain participants is paramount.* Williamson (2008) employs his prominent market-hybrid-hierarchy framework to analyse outsourcing activities from the TCE standpoints and proposes critical examination on the TCE and SCM relationships.

Economising is central to the transaction cost approach, hence, it is not surprising that an *economics literature* is among its antecedents. Further, although internal organisational issues are featured, the *organisation theory literature* makes an expected antecedent. The third literature, which is less obvious is the *contract law literature* in which contract is addressed as a governance issue (Williamson, 1981). All the *three antecedents* are appropriate for the study of SCFP in NLNG systems. First, because *economising* is a component of *cost minimisation* and *revenue maximisation,* which are established as the dominant SCFP drivers in study phases one and three (Figures 3.2; 6.1). In addition *revenue* and *cost* are ranked as the first and second most important measuring criteria respectively, by the relevant supply chain decision makers at NLNG in study phase two (Figure 5.4). Second, *organisation theory* is pertinent to SCFP in NLNG networks, and this study confirmed that internal organisation issues such as integration, information sharing, HSSE and capacity development are drivers of SCFP. Finally, *contract law* is a key feature of any LNG distribution network; Chapter two reveals that an NLNG supply chain is highly vertically integrated from natural gas extraction to distribution, and each chain relationship is governed by a robust contractual agreement, usually long-term in nature.

The determinants of transaction costs include assets specificity, bounded rationality, and opportunistic behaviour. *Bounded rationality* differs from both hyper-rationality and irrationality (Simon 1978). Organisations like NLNG may encounter challenges associated with powerful analytical and data-processing apparatus, however, such limitations do not imply irrationality. For bounded rationality, all economic exchanges could be efficiently organised by contracts such as gas purchase agreements, LTCs, and JVs. Given bounded rationality, however, it is impossible to deal with complexity in all contractually relevant respects (Williamson, 1981:553-554). Ubiquitous contracting would nevertheless be feasible if agents were not given to *opportunism*. If agents acted in good faith, comprehensive contracting would still be feasible. Principals would simply rely on promises from agents that they would behave in the manner of steward when unanticipated events occurred, while agents would reciprocally ask principals to behave in good faith (Williamson, 1981). This is true with SCFP drivers, where findings established that trust is a major factor influencing the key drivers, especially integration and collaboration and sourcing strategy. Moreover, NLNG addresses opportunism through collaboration with its long-term customers to explore alternative commercial initiatives such as the diverting of LNG cargos to high value markets as an arbitrage opportunity that benefits all parties to the LTC.

Transaction-specific investments are required to realise least cost to supply chains. The issue of *Asset specificity* is less when there are large fixed investments than when such investments are specialised in nature. Items that are unspecialised among users pose fewer risks, since buyers in these circumstances can easily turn to alternative sources and suppliers can sell output intended for one buyer to other buyers without difficulty. Non-marketability problems arise when the specific identity of the parties has important cost-bearing consequences. *Asset specificity* can arise in any of three ways: *site specificity*, when successive stations are located in close relation to each other so as to minimise inventory and transportation expenses. *Site specificity* is typical of LNG exporting plant where liquefaction, storage and shipment terminal are located on the same site. *Physical asset specificity*, where specialised dyes are required to produce a component, for example locating of NLNG plant at the Niger-Delta region that has abundant gas deposits. *Human asset specificity* arises from learning by doing.

3.8.2 Resource based view

During the 1990s, RBV became the prevalent strategic management theory, which proposes that a firm is a collection of unique and inimitable resources that offers the foundation for strategic competition and a major source of earnings. *The argument behind RBV is that companies enjoy performance benefits by integrating sets of resources to enhance organisational competences, which should be neither so simple to be copied by competitors, nor so difficult that it challenges internal control* (Shi and Yu, 2013). Being regarded as a leader in terms of inter-firm process capacity (Rai *et al.,* 2006), SCM assists in establishing such capabilities and leads to superior financial performance.

Barney's (1991) article is seen as pivotal in the emergence of RBV. Similar to TCE, RBV is an interdisciplinary framework that represents a substantial paradigm shift (Fahy and Smithee, 1999). RBV was developed within the disciplines of economics, ethics, law, management, marketing, SCM and general business (Hunt, 2013). Recent studies have paid attention to the utilisation of RBV in SCFP; Seggie *et al.* (2006) employ RBV to study the impact of precise IT resources, such as IT alignment and supply chain communication structures on brand equity and company performance. Zhu and Kraemer (2002) draw on RBV and illustrate the relationship between financial performance and e-commerce resources for manufacturing companies. Gold *et al.* (2009) review relevant RBV literature and extend its application to inter-firm level and establish how supply chain *collaboration* on environmental and social issues engenders network *sustainable* competitive advantages.

RBV proposes that organisations are heterogeneous because they possess heterogeneous resources, meaning that organisations can have different strategies because they have different resource combinations (Barney, 1991). This is pertinent to NLNG supply chain systems, where the main reason for establishing an LNG exporting network is availability of natural gas resources. In addition, findings revealed that other resources are required, such as human resource, integration, IT and automation for an NLNG supply chain to achieve sustainable competitive advantage. RBV focuses managerial attention on internal resources in an effort to identify those assets, capabilities and competencies with the potential to deliver superior competitive advantage and sustainability, encompassing NLNG SCFP.

3.9 Confirmation and validation of study phase one findings

To minimise bias, a scoping study was conducted with supply chain experts at NLNG to substantiate and validate whether the identified SCM practices and measures established in study phase one drive financial performance in NLNG distribution systems. Scoping study corroborates the theoretical template findings that *sourcing strategy*, *IT and automation, integration and collaborations and sustainable* SCM initiatives drives financial performance in NLNG systems.

NLNG supply chain professionals also upheld that NLNG SCFP are measured using *cost, revenue, working capital and assets utilisation*. In addition, study phase one preliminary findings were presented to academics at the Logistics Research Network for further validation. SCF researchers validated key findings and suggested that tax liability should be considered as a measure of financial performance. To minimise bias, Experts' opinion was considered and the final coding template was reviewed by the researcher under a close supervision by an experienced researcher in SCF and a highly experienced researcher in logistics and supply chains to check whether tax should be a higher-order theme. There was a 100% agreement by all the three researchers involved in the review process that tax liability is only a sub-theme under *cost minimisation* (Durach *et al.*, 2017).

3.10 Summary of chapter three

This chapter synthesised strategic drivers, capabilities and measures of SCFP. This study systematically reviewed SCFP related publications covering 20 years, between 1999 and 2018, and analysed how SCM capabilities that drive financial performance evolved and proposed an updated generic taxonomy and conceptual framework of SCFP in study phase one. Template analysis of the data set identified *sourcing strategy, information technology and automation, integration and collaborations and sustainability* as critical supply chain initiatives that drive financial results. In addition, the financial performance of this phenomenon can be measured using traditional financial measures, including *asset utilisation, working capital, revenue and cost*. An optimal level of *integration* is essential to realise the full financial advantages of effective SCM.

As established by template analysis of empirical SCF literature, the taxonomy and framework proposed in study phase one are underpinned by TCE and RBV. According to TCE and RBV, effective SCM contributes significantly to business performance, including financial performance. The level of performance between these strategies depends on the extent of the interconnectivity between each strategy, explaining why *integration and collaboration* is integral to optimising financial performance. The next chapter discusses research methodologies applicable to SCFP in NLNG systems.

Chapter four: Research methodology

4.1 Chapter four overview

Methodology is concerned with the rationale behind the procedures used to research what it is believed is possible to be known. It provides a researcher with guidelines as to why was the data collected, from where was the data collected, when the data was collected, and how was the data collected and analysed (Howell, 2013; Creswell, 1994; Guba and Lincoln, 1994). In study phase one, problems were identified from a preliminary review of literature from which a research question was formulated: *how can operators in NLNG systems improve SCFP?* The ultimate objective of this study is to address the research question by proposing strategies and policies to improve SCFP in NLNG systems. To achieve this aim, a mixed methodology will utilise both quantitative and qualitative methods, to build a substantive taxonomy within a pragmatic paradigm of enquiry.

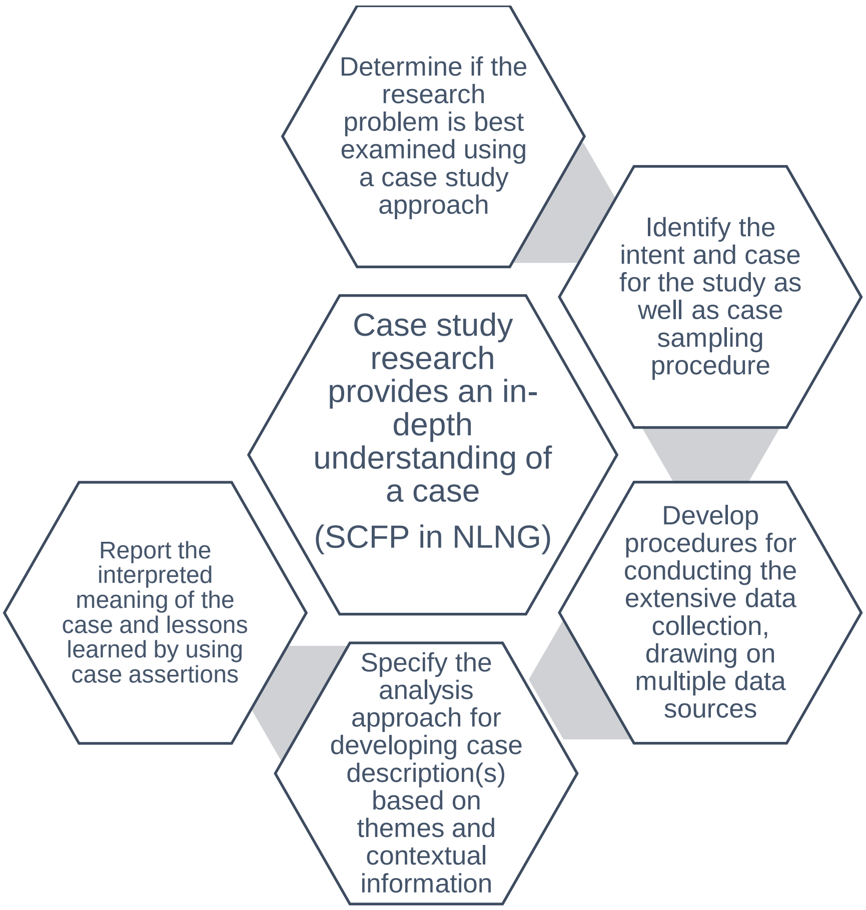
The first section of this chapter presents the research methodology that was used in this study. The second section presents methods of data collection, and template analysis and AHP are presented as methods of data analysis in the third section.

4.2 Research methodology

Methodology involves how to think about and to study social reality (Strauss and Corbin, 1990). Methodology is a way of thinking about studying a social phenomenon (Corbin and Strauss, 2008, p.1). Methodology is the overall approach to the research process, from theoretical application to the collection and analysis of data (Creswell and Poth 2018; Wilson, 2014). A case study (Creswell and Poth, 2018; Merriam and Tisdell, 2015; Mertens, 2015; Yin*,* 2014; Denzin and Lincoln, 2011; Denzin and Lincoln, 2005) was selected as an appropriate strategy for this study that aims to generate insights regarding SCFP in the LNG industry from the context of NLNG. Methodologies, including case studies, are selected to offer the best available approach to tackle particular research questions (Dinwoodie and Xu, 2008). A case study is an in-depth study into a topic or a phenomenon within its real life contemporary setting or context (Saunders *et al.,* 2016; Yin*,* 2014).

Objectives four and five aim to access the SCFP capabilities of NLNG systems and subsequently propose a taxonomy that to defines SCFP in NLNG networks. Deployments of case study in logistics and SCM must reflect what is being investigated, and why (Dinwoodie and Xu, 2008). A case study strategy offers the scope to generate insights from a rigorous research into the study of a phenomenon in its real-life context, leading to rich, empirical descriptions and development of theory (Yin, 2014; Dubois and Gadde, 2002). The interaction between a phenomenon and its context is better understood through intensive case studies. An in-depth inquiry can be designed to ascertain what drives SCFP in NLNG systems and why, and perhaps to understand the effects of supply chain strategy to financial performance and influences for action (Dubois and Gadde, 2002) (Figure 4.1). To achieve such insights, case study research draws on quantitative or qualitative research and frequently uses a mixed methods approach, to fully understand the dynamics of the phenomenon (Saunders *et al.,* 2016). This study employs mixed methods of data collection and analysis to fully apprehend expert opinion regarding the SCM strategies that drives financial performance within NLNG as the case study.

Figure 4.1: Procedure for conducting case study research



Source: Creswell and Poth (2018:101)

4.2.1 Nigeria liquefied natural gas limited as a case study

It will be remarkable if a multisite case study (Creswell and Poth, 2018; Dinwoodie and Xu, 2008) can be conducted to collect data from the five major LNG exporting countries, Qatar, Australia, Malaysia, Nigeria and Indonesia, and draw more generalised conclusions towards proposing strategies and policies to improve SCFP to stakeholders in LNG industry. However, such a population is difficult to research as not all key elements may be known to the researcher, in addition to constraints such as time, resource and access to these mega multinational gas companies. This study adopted a single case or within-site study (Creswell and Poth, 2018) of NLNG to address the research question of: *how can operators in*

NLNG systems improve SCFP? One thing remains crucial when selecting any sample: it must enable a researcher to address the research question (Saunders *et al.,* 2016).

In-depth qualitative and quantitative information were gathered from multiple sources, including interviews, surveys, documents and reports relevant to NLNG SCFP. A case study is a methodology in which the investigator explores a real-life, contemporary bounded system through detailed, in-depth data collection involving multiple sources of data and reports a case description and themes (Creswell and Poth, 2018). This study being a single case research, findings are only generalizable to NLNG systems. However, many findings are applicable to other major LNG exporting countries due to the homogeneous and standardised nature of LNG supply chains.

4.3 Methods of data collection

Methods of data collection are the techniques and procedures used to obtain and analyse data (Saunders *et al.*, 2016). To enhance the quality of a case study design, three key principles to be considered during the data collection phase include triangulation, case study database and chain of evidence (Yin, 2003). First, triangulation refers to using data from different sources to arrive at findings. Triangulation is one of the tools that can be used to assure the construct validity in a case study research (Yin, 2003). Multiple quantitative and qualitative data sources can be used in triangulation. The appropriate sources should be selected with respect to the problem and research questions being addressed (Cooper and Morgan, 2008). Multiple data sources relevant to SCFP in NLNG were utilised to address the research question. Triangulation is deployed in logistics and SCM case studies to explore theory, validate models, refine and extend theory using multiple evidences to review theory through multiple comparisons (Dinwoodie and Xu, 2008). Second, a well-organised database of the evidence collected is needed to facilitate the replicability of the study and increase the reliability of the information in a case study. Third, maintaining a chain of evidence increases the construct validity of a case study (Yin, 2003).

Data are divided into primary and secondary, and qualitative and quantitative data respectively (Howell, 2013). Primary data consist of interviews, surveys and observations which are usually collected for a specific study, while secondary data come from information which have already been issued (Wilson, 2014). Qualitative methods present a dynamic view of social life, and quantitative methods provide a static account (Bryman, 1988). Triangulation, which combines both qualitative and quantitative methods, facilitates the overcoming of deficiencies that might arise from either method (Denzin, 1978). Researchers are likely to show greater confidence in their findings when they are the product of more than one method of investigation (Bryman, 1989). Combining multiple data collection methods in a study allows for in-depth collection of information and opens enormous opportunities for shared advantages in each of the key stages of design, data collection, and analysis (Denzin, 1978). A mixed methods approach was employed for this study. Convergence between qualitative and quantitative methods enhance confidence that findings are valid because of two-way testing. Quantitative methods test the generic variables of SCFP in NLNG settings which measure relationships, but it is difficult to identify any new factor. However, qualitative methods were applied to assist in achieving a closer relationship with the subject, which allowed for discovery of latent factors that might not have been taken into consideration.

Triangulation facilitates the use of multiple sources, methods, investigators and theories to provide supporting evidence for validating the accuracy of findings. The triangulation process involves collecting information from a range of individuals and groups using more than one source of data collection, combining both quantitative and qualitative methods to confirm the validity, credibility, authenticity of data, analysis and interpretation and minimise the risk that the conclusions may only reflect the systematic biases (Creswell and Poth, 2018; Saunders *et al.,* 2016; Howell, 2013). To safeguard validity and reliability, triangulation between different sources and methods, was used for this study which collected both primary data in the form of interviews and surveys, as well as secondary data from documents and literature studies, to identify, analyse and synthesise the drivers of SCFP in NLNG networks and to propose strategies to improve SCFP in NLNG systems. The process of using multiple insights to clarify meaning, verify the repeatability of an observation or interpretation helps to categorise similar and different realities (Stake, 2008; Dinwoodie and Xu, 2008). Analysis and findings are produced from each method utilised (Caniato *et al*, 2016). The collection of primary data was conducted online using specialist research software, Qualtrics (Appendices 4; 5; 6). Emails and phone calls were made as reminders to heighten the response rate. A reminder is essential to enhance response rates (Wilson, 2014).

4.3.1 Sampling technique

For all research questions where it would be impracticable to collect information from the entire population due to access, time, *cost* and ethical considerations, researchers need to select a sample. Sampling provides a valid alternative to a census when it is not possible to collect data from an entire population (Saunders *et al.,* 2016). Many researchers such as Barnett (2002) argued that using sampling makes possible a higher overall accuracy than a census. Gathering data from fewer cases also means a researcher can collect more detailed information. However, the sample selected must be related to the population that is highlighted in the research question and objectives. When selecting a sample, it must enable the researcher to address the research question (Saunders *et al.,* 2016; Edwards and Holland, 2013).

The techniques for sampling can be divided into two types, probability or representative sampling and non-probability or non-random sampling (Saunders *et al*., 2016). However, within business research, such as market surveys and case study research, probability sampling may either not be possible as the researcher does not have a sampling frame and may not be appropriate to addressing your research question. For business and management study, research question, objectives and choice of research strategy may dictate non-probability sampling. To address a research question and to meet research objectives, a researcher may need to undertake a comprehensive study that focuses on a case or cases selected for a particular purpose. Non-probability sampling would provide an information-rich case study in which to explore research question and gain theoretical insights (Saunders *et al*., 2016). Non-probability sampling was selected as the appropriate technique to address the research question and to achieve the objectives of this study focusing specifically on proposing strategies that will improve SCFP in NLNG systems.

Purposive sampling was selected as a type of non-probability technique. Using purposive sampling a researcher needs to use her own judgement to select cases that will best address the research question and to meet target objectives (Saunders *et al.* 2016). To achieve the objectives of this study, it is essential to collect tacit SCFP strategic decision-making information relevant to NLNG systems. This makes supply chain strategic decision-makers at NLNG the target respondents for empirical data collection. However, a researcher needs to think carefully regarding the impact of the judgement when deciding whether to include or exclude cases (Saunders, *et al.,* 2016). When selecting the respondents, the researcher worked meticulously with two experienced staff of NLNG and identified the key divisions that are involved with SCM strategies that affect financial performance, and pinpointed the personnel that carry out decision-making responsibilities with financial influences for NLNG supply chains. Purposive sampling intentionally samples a group of participants that best inform the researcher about the research problem under investigation (Creswell and Poth, 2018, Creswell and Creswell, 2018).

Heterogeneous or maximum variation sampling strategies were used as a strategy for purposive sampling. Heterogeneous sampling uses a researcher's judgement to select participants with different characteristics to provide the maximum variation possible in the data collected. It enables collection of data to describe and explain the key themes that can be observed (Saunders *et al.* 2016). Although this might seem a contradiction, as a small sample may comprise cases that are totally different, however, it is argued that this is rather a strength. Any patterns that do develop are likely to be of specific interest and value and represent the key themes. In addition, the data collected should enable a researcher to document uniqueness (Patton, 2002). Although a majority of the participants for this study were identified from four key divisions due to their involvement in SCM strategy, heterogeneous sampling enabled the collection of data from any division where relevant data was identified.

4.3.2 Research framework and triangulation

Triangulation of quantitative and qualitative methods was conducted in this study which seeks to gain insights into identifying the supply chain capabilities that drive financial performance about which little is known in NLNG networks, to propose strategies and policies to improve SCFP in NLNG systems.

This study adopted a sequential approach framework (Mangan *et al.,* 2004) where both qualitative and quantitative methods are applied at different phases of the research. Results from one phase are further refined to be used in the next phase. There could be three different ways of mixing quantitative and qualitative research. First, employing qualitative research to explore a topic to set up a quantitative study. Second, starting with a quantitative study to establish sample respondents and to establish the peculiarities of the study area. Qualitative research can be used to look in-depth at a key issue using some of the earlier sample. Third, engaging in a qualitative study which uses quantitative data to identify the results in a broader context (Silverman, 2006). This study was conducted through a pragmatic lens (Dewey, 1950) and employed a mixed approach where qualitative and quantitative research were conducted simultaneously across all phases (Table 4.1). Phase one utilised qualitative data from literature and archival studies, as well as quantitative statistical data. Phase two deployed surveys with NLNG to measure the SCFP constructs identified from phase one. Phase three conducted qualitative semi-structured interviews to identify latent factors and expert opinion to gain a better understanding of key issues relevant to improving SCFP in NLNG systems (Table 4.1).

The SCFP systematic literature review in study phase one was used to collect descriptive or explanatory data to identify generic constructs of SCFP. The quantitative survey AHP was used to measure preferences of the construct in the NLNG case study and to evaluate the optimal SCFP strategy in NLNG systems. Semi-structured interviews were conducted to inductively assess other factors that could not be identified in extant SCFP related literature that might introduce some element of bias in the survey instrument. The combination of these methods provided an effective way to triangulate data collected, which prevents limiting the findings to only variables included in the survey.

Table 4.1: Synopsis of the research framework

Phase	Research objectives	Research methods	Research strategies	Results
One: Exploratory study	Objectives 1 and 2	Mixed (qualitative & quantitative)	LNG literature; archival study	Identify the characteristics and objectives of LNG supply chain system
	Objective 3	Qualitative	SCFP literature	Develop a generic taxonomy and theoretical framework of SCFP
Two: Quantitative Case study	Objectives 4 and 6	Quantitative	Surveys	Measure and priorities SCFP, and proposed strategies and policies to improve SCFP in NLNG networks drivers in NLNG systems
Three: Qualitative Case study	Objectives 5 and 6	Qualitative	Semi-structured interviews	Propose an explicit taxonomy and empirical framework of SCFP and propose strategies and policies to improve SCFP in NLNG networks

Source: Author

4.4 Qualitative methods of data collection

This study employed established qualitative data collection strategies such as archival studies, literature review and semi-structured interviews (Creswell and Poth, 2018; Saunders *et al.*, 2016; Wang and Bowie, 2009; Dinwoodie and Xu, 2008). Qualitative interviews entail interactional exchange of dialogue between the researcher and the participants, in face-to-face or other contexts (Edwards and Holland, 2013). Qualitative interviews revolve around themes and topics which allow access to participants' situations and contextual opinions, experiences and knowledge (Edward and Holland, 2013). Interviews enable this study to gather valuable opinions, experiences and concerns of practitioners regarding SCFP in NLNG systems. Furthermore, secondary data are sourced from literature, reports, bulletins and relevant energy, supply chain, finance and shipping agencies to facilitate a valid conclusion (Saunders *et al.*, 2016; Howell, 2013).

4.4.1 Semi-structured interviews

Semi-structured interviews were conducted individually with identified supply chain strategy experts and key decision-makers at NLNG. A typical semi-structured interview has a list of topics expressed in a prompt-sheet which the researcher wants to cover (Edwards and Holland, 2013). Fifteen semi-structured interviews were conducted asynchronously using specialised online software (Chen and Hinton, 1999), between March 2018 and June 2018. Most qualitative studies use synchronous face-to-face interviews, which allows the researcher to extract valuable data not only from the spoken responses, but also tacit data from respondents' facial expression, silent approvals, hand gestures and body movements (Edwards and Holland 2013; Howell, 2013). Due to the sensitivity of the LNG sector and the petroleum industry in general, access for face-to-face interviews was not available. Consequently, TBEI in the form of online questionnaires (Saunders *et al.,* 2016; Edwards and Holland, 2013) were conducted. TBEI have been used with great success, especially for interviewees located in overseas countries (Chen and Hinton).

TBEI requires the researcher to frame questions to a capable browser software; Qualtrics software was used in this study (Appendix 4). Using a webpage as an interviewing interface between the interviewer and their subject, the interviewer is able to question the subject by logging the discussion to a file that serves as a permanent transcript of the interview (Chen and Hinton, 1999). A major challenge for TBEI is that all non-verbal communication is lost and the method does not empower the researcher to conduct observation-based research during the course of the interview (Chen and Hinton, 1999) (Table 2.2).

Table 4.2: Benefits and drawbacks of electronic interviews

Strengths	Drawbacks
▪ Cost savings ▪ Objectivity of subjects through anonymity ▪ Sample bias reduction: Access to busy people, non-responders geographic reach ▪ Flexibility of time and place ▪ Speed, quick to establish, run and post analysis is faster because of lack of transcription	▪ Qualitative nature of research method ▪ Lack of facial expression ▪ Development of expertise ▪ Access to computer is necessary for participants ▪ Instruction and clarification

Source: Chen and Hinton (1999).

Key concerns with TBEI such as development of expertise, computer literacy and access, and instruction and clarification were addressed. A copy of interview questions and definitions of terms was sent to participants for familiarisation and clarification prior to interviewing. A questionnaire interview guide (Appendix 3) was also attached to the email sent to respondents.

TBEI considerably improved the quality of this study by giving the respondents more time to think and reflect before responding. The online questionnaires also eased respondents' concerns at of being observed and recorded face-to-face. TBEI may be advantageous in terms of allowing time for reflection in terms of providing a considered response (Saunders *et al.,* 2016). Another major advantage of online questionnaires is that they help to preserve data accuracy and validity by minimising transcription errors, because it allows respondents to write their responses directly. Data are recorded as they are typed in all forms of TBEI, thereby removing problems associated with other forms of recording and transcription such as *cost*, accuracy and participants' apprehension (Saunders *et al.,* 2016). TBEI also attracted more response, giving the very busy NLNG professionals targeted for this exercise the flexibility to answer the questions at their most convenient time.

To achieve the research objectives and address the research question, the researcher employed purposive sampling (Creswell and Poth, 2018, Creswell and Creswell, 2018) as discussed above. The researcher worked closely with gatekeepers (Creswell and Creswell, 2018; Saunders *et al.,* 2016) at NLNG to identify appropriate respondents that carryout strategic decision-making responsibilities which have financial influence for NLNG supply chains. This study mainly acquires or explores the opinions, thoughts, concerns and perspectives of NLNG supply chain professionals regarding SCFP in NLNG systems. Consequently, 32 experts were approached from relevant divisions of NLNG including Finance, Production, Shipping, External Relations, MD, and Deputy Managing Director divisions respectively. A saturation was reached after a total of 15 experts granted interviews, in which each of the target divisions was represented. Data collection should end where saturation is reached. A saturation is a point where enough data was gathered and there was no new information emerging (Creswell and Poth, 2018).

Technology significantly facilitated the successful delivery of interviews, especially due to the interviewees' unavailability within a feasible period as well as geographical distance between the case study and the research centre. Using this approach, the researcher has developed rapport with interviewees where the process was carefully prepared, including sending pre-interview information to participants, taking into account any cultural differences and need to gain familiarity with the technology.

4.4.2 Qualitative archival studies

Within business and management research archival secondary data are used most frequently as part of a case study or survey research strategy (Saunders *et al.,* 2016). Along with quantitative achieved data, qualitative records relevant to NLNG SCFP including journals, bulletins, company policy, standard practices, training and health safety and environment (HSE) manuals, relevant energy websites were accessed which enhanced understanding and helped to address the research question. Researchers may collect qualitative organisational and public documents such as newspapers, minutes of meetings reports and strategic plans to achieve set objectives (Creswell and Creswell, 2018).

Due to the size, competitiveness and regulations of the LNG industry, key supply chain participants and stakeholder agencies regularly published reports that are vital supply chain performance which were utilised as data in this study. Archival study allows data to be transposed across both time and space and reanalysed for a purpose different to that for which documents were originally collected (Lee, 2012).

4.4.3 Systematic literature search

Given the infancy of SCFP research, and the limited amount of quality literature in this important field, articles with qualitative and quantitative approaches to data collection techniques and analysis are considered to enable a rigorous pragmatic study (Saunders *et al.,* 2016).

An extensive systematic literature searches interrogated academic databases using a specialist university library access (Kuznetsov *et al*., 2017). Literature searches were limited to publications between 1999 and 2018, encompassing the 2008 financial downturn, which stimulated interest in SCF as financial crises stimulated interest in SCF as financial crises promulgated solutions and programmes to optimise *working capital* (Caniato *et al.,* 2016). Initially, the keyword "supply chain financial performance" was successively entered into the "title", and "title or abstract" field. After reading articles, a second filter excluded papers unrelated to SCFP drivers, practices, strategy, measures or the linkages through which supply chain practices affect financial performance. Cross-referencing was used to identify other related articles and minimise selection bias (Yawar and Seuring, 2017).

The data gathered from the systematic literature search was analysed using template analysis (King and Brooks, 2017; Saunders *et al.,* 2016; Brooks *et al.,* 2015) to arrive at study phase one findings which were used to develop a generic typology and the conceptual framework (Figure 3.2), as well as an empirical data collection instrument (Appendix 5).

4.5 Quantitative methods of data collection

In addition to the qualitative data collected, this study employed quantitative strategies of data collection in the form of industry statistical data and surveys conducted with supply chain experts in NLNG (Saunders *et al.,* 2016; Dinwoodie and Xu, 2008). Quantitative research methods such as quantitative modelling and simulation are well-established techniques for data collection. However, survey is the most frequently used quantitative method of data collection in the social science research and case studies (Taylor and Taylor, 2009). Recent studies have shown a sizable increase in the quantity and quality of surveys in social science research (Rungtusanatham *et al.,* 2003). Surveys provide plans for a quantitative description of trends, attitudes, or opinion of a population by studying a sample of that population (Creswell and Creswell, 2018). Two set of surveys are used for this study, AHP and Likert-scale respectively (Appendices 5 and 6). AHP surveys helped in collecting subjective expert opinions to measure and rank how various supply chain capabilities that drive financial performance in NLNG systems. Likert-scale survey assisted in measuring factors that influence SCFP capabilities in NLNG networks.

Surveys helped in validating and redefining the constructs of SCFP derived from theory in a practical setting. Survey research has contributed significantly to the advancement of management studies by providing evidence for validation and adjustment to theories (Boyer and Swink, 2008; Craighead *et al.,* 2011). There are arguments against using quantitative data such as surveys in social science research. In most instances, social science research phenomena are a function of perception, beliefs and experiences that is difficult to measure objectively (Howell, 2013). Advancement in management studies requires greater use of qualitative methods as the use of quantitative methods displays many weaknesses. The complex and multivariate nature of problems investigated, the validity of assumptions upon which the design and results are based is questionable. Phenomena are studied in isolation of their context, which raises questions regarding the assumed causal relationships among variables (Kiridena and Fitzgerald, 2006). To address this problem this study employed a mixed approach to empirical data collection, where both surveys and interviews are deployed with experts in NLNG. To minimise the gap between theory and practice and increase the practical influences of social science research, contemporary research has shifted towards the use of empirical research to supplement mathematics, modelling and simulation to develop and test theories (Forza, 2002).

4.5.1 Analytical hierarchy process survey

One of the most recognised multi-criteria decision-making (MCDM) techniques is AHP (Saaty, 1980), which was established to obtain the relative weights among the factors and the total values of each alternative based on these weights (Torfi *et al.* 2010). In comparison with other MCDM methods, AHP has been widely applied successfully in many practical decision-making problems (Saaty, 1988). AHP uses procedures for measuring variables based on pairwise comparisons between criteria and between alternatives (Rangone, 1996). AHP process makes it possible to incorporate judgements on intangible qualitative criteria alongside tangible quantitative criteria (Badri, 2001).

The AHP survey instrument was developed from the generic taxonomy and conceptual framework of SCFP (Figure 3.2) which was established from systematic literature review of extant literature relevant to SCFP conducted in study phase one, which was validated by industry experts during scoping studies (Section 3.9). Consistent with the findings of systematic literature analysis, the survey questions consist of four criteria, which are expected to find the relative priorities or preferences and their weights. Prioritising the established SCPF drivers will enable this study to propose the optimal strategies to improve SCFP in NLNG systems, which is the overarching objective of this research. For validity and clarity, the survey instrument was reviewed three times discretely by two academics with vast experience in using similar method in SCM studies, and further reviewed by two separate NLNG professionals. Key considerations when designing questions are their content, structure, format and sequence (Nachmias and Nachmias, 1996). The questions in this study were designed in a manner to help respondents complete the questionnaire thoughtfully but not at high cost of time and effort.

After establishing AHP hierarchies, data collection should take place to allocate the pair-wise comparisons (Rajesh and Malliga, 2013). The 9-point scale (Table 4.3) proposed by Saaty and Vargas (2012a) was used to allocate the relative scores based on degree of importance (Jayawickrama, *et al.,* 2017). To achieve this a bi-polar questionnaire (Appendix 5) was designed to facilitate comparison of the importance of SCFP drivers in NLNG systems. For ease of administration, access and clarity, the questionnaire was developed on Qualtrics software with nine options ranging from: “absolutely more important (9)”; “demonstrably more important (7)”; “strongly more important (5)”; “slightly more important (3)”; and “equally important (1)” (Elgazzar *et al.,* 2012) (Table 4.3). The first section of the questionnaire is a pairwise comparison of one NLNG SCFP measurement criteria over another in which respondents are expected to select six options out of fifty-four options based on importance or preference. The second set of questions are paired comparisons which measure the extent to which each SCFP driver influences SCFP measures in NLNG; these questions consist of 216 options of which respondents are to select only 24 options. AHP is used for preference measurement for both decision-making criteria and alternatives (Saaty, 1988).

Table 4.3: Questionnaire form to facilitate comparison of factors

Attribute	Absolutely more important (9)	Demonstrably more important (7)	Strongly more important (5)	Slightly more important (3)	Equally important (1)	Slightly more important (3)	Strongly more important (5)	Demonstrably more important (7)	Absolutely more important (9)	Attribute

Source: Elgazzar *et al.* (2012:284)

Twenty-three out of the selected 32 (72%) of the targeted NLNG supply chain experts answered the AHP questionnaire. There was good representation from all the key divisions where strategic decisions with SCFP influences are taken including Finance, Production, Shipping, External Relations, MD, and Deputy Managing Director divisions accordingly. This assisted in capturing or acquiring experts' opinions regarding the contribution of each strategic SCFP driver to financial performance in NLNG systems.

4.5.2 Likert-scale survey

Although many different types of measures exist, a majority of survey questionnaires historically used Likert-scales (Schmitt *et al.*, 1991). The Likert-scale was first developed to detect a respondent's attitude or opinion (Wilson, 2014). A Likert-scale was developed to systematically code data through a numerical scale. The survey requires participants to "agree" or "disagree" with given statements on a scale of usually one to five (Howell, 2003). The data collection instrument for this study comprises a Likert-scale survey to measure the factors that influence SCFP competencies in NLNG systems. Each item is measured through five-point Likert-scales (Howell, 2003). There are 30 Likert-scale questions that are administered via the online data collection instrument (Appendix 6).

4.5.3 Quantitative archival studies

In addition to archived qualitative data, statistical records relevant to NLNG SCFP such as number and size of trains, tanks, vessels, port terminals, feedgas supply, supply disruptions, LNG distributed, and accident rates were accessed from key supply chain participants and stakeholder agencies database. These statistical data assisted towards addressing the research question (Creswell and Creswell, 2018).

Table 4.4: Summary of data collection methods utilised

Data source	Qualitative methods	Quantitative methods
Primary	Semi-structured interviews	AHP bi-polar surveys
	-	Likert-scale surveys
Secondary	Qualitative archival studies	Quantitative archival studies
	Systematic literature data	-

Source: Author

4.6 Data analysis and representation

The process of analysis is much more than an approach for analysing text and image data. It involves other interconnected steps such as organising the data, conducting preliminary read-through of database, coding and analysing themes, representing the data, and forming an interpretation of those data (Creswell and Poth, 2018). Authors of qualitative research present different perspectives of data analysis, such as an interpretive approach framework taken from critical ethnography (Madison, 2011; 2005), a systematic approach to analysis (Huberman and Miles, 1994), and traditional approaches ranging from ethnography to case study analysis (Walcott, 1994). However, these authors agreed on the central steps of qualitative data analysis, which are: preparing and organising the data, reducing the data into themes through coding and condensing the codes, and representing the data in figures, tables, graphs, charts or a discussion (Creswell and Poth, 2018).

This case study research followed an approach similar to that presented by Walcott (1994) which discusses the importance of forming a description from the data, relating the description to literature and cultural themes. The study draws its empirical research instrument from both literature and industry publications, which was then tested at NLNG as case study. This also conforms to the conclusion of Yin (2014) who presented three major strategies for case study analysis, which are relying on theoretical propositions, thinking about opposing explanations, and developing a case description. First, relying on theoretical propositions involves research questions, reviews of literature and generation of new hypotheses or propositions. Based on such propositions the research objectives, case design and data collection plan are developed. In study phase one, a theoretical position technique was applied by collecting extant SCFP related literature and analysing it using template analysis to propose a typology for SCFP, which was eventually utilised to develop an AHP questionnaire in study phase two. Second, to define and test opposing accounts of the case, which is suitable in evaluative case studies. This strategy was utilised to assess and analyse SCFP characteristics of other competing LNG countries with SCFP attributes similar to NLNG. Third, to analyse a case study by developing a descriptive framework. This could serve as an alternative where there is a difficulty in implementing the other two strategies, and is also relevant to descriptive studies, and may help in situations when identification of cause and effect needs to be analysed (Yin *et al.,* 2014). This study developed a conceptual framework (Figure 3.2) from its initial temple.

There are no specific procedures to be followed for a case study. However, research analysis should utilise all the relevant evidence, demonstrate all major competing interpretations and address the most significant aspect of the case study. This study used mixed methods of data collection (Creswell and Creswell, 2013) which facilitated data triangulation (Yin, 2003), analysed text and numerical data using templates, AHP models, tables, charts, graphs, and narrative form.

4.7 Research methods, models, techniques for analysis

The key scientific research methods used for this study are template analysis (King and Brooks, 2017; Brooks *et al.,* 2015) and AHP (Saaty, 1980). Template analysis helps in analysing qualitative systematic literature data collected in study phase one, which assists towards achieving objectives three and six of this study. Template analysis was also used to analyse semi-structured interviews conducted in phase three to establish a taxonomy and empirical framework of SCFP in NLNG systems and proposed strategies and policies to improve SCFP in NLNG networks.

4.8 Template analysis

Template analysis was utilised to build a taxonomy of SCFP. Template facilitates theory building (McCluskey *et al*., 2011) and ensures replicability, using hierarchical coding to balance a structured process of analysing textual data with the flexibility for modification where needed (King and Brooks, 2017; Saunders *et al.,* 2016; Brooks *et al.,* 2015).

4.8.1 Fundamentals of template analysis

During template analysis an initial coding template is developed, typically based on a subset of data, which is subsequently revised and refined as further data emerge to form the final template (Brooks *et al*., 2015). In this study, categories for initial theoretical coding template were established deductively from Shi and Yu's (2013) definition of SCFP as higher-order themes (Appendix one). Subsequently, the initial theoretical template was applied to further data set from the remaining qualifying articles and modified as relevant to form the final theoretical template and the generic taxonomy of SCFP (Appendix 2). A template analysis homogenous to study phase one template was applied to the interview data to develop the initial and final empirical templates (Appendices 17; 18) which proposed an empirical taxonomy and a framework of SCFP in NLNG systems (Figure 6.2).

In conducting template analysis, the researcher was closely supervised by experienced researchers in SCF and a highly experienced researcher in logistics and supply chains. Themes were defined through discussion in the light of the research objectives and through drawing on key issues emerging from the dataset. For example, modified codes included broad themes identified as a priority by the researcher (issues around the concept of *sustainability*) and themes determined by the research aims (*assets utilisation*). Over a period of six months, the research team met at regular intervals to examine how the template evolved. Supervised working strategy is valuable, as the process necessitates clear agreement and justification for the inclusion of each code, and a clear definition of its use. Any additions were reviewed at regular research meetings, and the template was updated. Decisions regarding when a template is "good enough" are project-specific and inevitably face pragmatic external constraints (Brooks *et al*., 2015:209; King *et al.,* 2013). In this project, by version four of the theoretical template (Appendix 2) and version two of the empirical template (Appendix 18), all supervisory team members agreed that the template covered all sections of data gathered adequately. The resulting supervisory sessions of data analysis meant that all team members understood the template well. Template analysis facilitated the development of generic and industry specific taxonomies of SCFP, offering an appropriate method where prior work is scant.

4.8.2 Procedure for template analysis

King and Brooks (2017) established that template analysis is a process undertaken in sequence of seven steps, which consist of familiarization with data, preliminary coding, clustering, producing initial template, developing template, applying the final template and final interpretation/writing up:

1. Familiarization with data

Before the commencement of systematic analysis in this study, the researcher read through transcripts of systematic literature in study phase one and interviews in study phase three several times for familiarization. Greater familiarization with the data enables the researcher to carry out high-quality SCFP analysis.

2. Preliminary coding

Preliminary coding is usually carried out on a sub-set of data. At this stage, the researcher coded the first four of fifteen interviews, noting data items that may be relevant to addressing the research question *(how can operators at NLNG* *systems improve SCFP?)* and highlighted points of interest and look out for material that supports a priori themes.

3. Clustering

On the basis of the preliminary analysis, emerging SCFP related themes are clustered into meaningful groups in hierarchical order, with higher-order themes encompassing one or more levels of more narrowly focused themes.

4. Producing initial templates

The clusters of themes served as the basis for producing initial templates in study phase one and study phase three. The initial templates are presented with diagrams showing hierarchical organisation within each cluster (Appendices 1; 17).

5. Developing final templates

The initial templates are then applied to further data set. The final template is amended where faults are found in how well it captures what is relevant to SCFP in the data and the template is modified in an iterative manner.

6. Applying the final template

Once there are no significant modifications needed and all relevant SCFP data are covered, the full data set is coded to the final template (Appendices 2; 18). The templates were utilised to develop interpretation in study phase one and study phase three.

7. Final interpretation/writing up

Final templates were used to organise the way analysis was presented to define a generic construct of SCFP in study phase one and an explicit taxonomy of SCFP in NLNG systems in study phase three.

4.8.3 Template presentation

Categories of themes are presented using numbers, colour codes, or varied font sizes and styles (King and Brooks, 2017). These themes are presented at different order levels depending on the nature and the objective of study. Template analysis does not suggest in advance a set sequence of coding levels but rather encourages research to develop themes expansively where the richest data relevant to SCFP are found and does not insist on a specific distinction between descriptive and interpretive codes (Brooks *et al*., 2015). In this study, categories span from two to five levels depending on the breadth of a group. The order signifies the relative importance of the categories commencing with level one higher-order themes, which represent the most important drivers and measures respectively (Appendices 1; 2; 17; 18).

4.8.4 Strengths and limitations of template analysis

This study encountered and addressed all the five challenges associated with template analysis, including generic nature, fragmentation of accounts, procedure as prescription, much flexibility, and limited guidance on the final interpretation (King and Brooks, 2017):

1. The generic nature of template analysis

Template analysis facilitated the development of SCFP taxonomies in study phase one and study phase three, offering generic and explicit method where prior work is scant. Template analysis avoids ties with any specific philosophy, which may be limiting. The challenge here was working out the researcher’s own philosophical and theoretical position of the research. The lack of philosophical underpinning to a philosophical position can mean lack of clarity in a researcher’s position. However, every study has a philosophical position; it is just that it does not have to be made explicit.

2. The fragmentation of accounts

Template analysis, like all thematic approaches produces fragmented accounts, potentially confounding researchers who are seeking to understand experiences of the whole person, rather than seeing them as an aggregation of variables. However, fragmentation is likely to be significant when the sample is large, and this study only targeted strategic decision-makers on a single case study. Strategies such as case summaries and the presentation of findings through case studies are valuable for retaining holistic accounts.

3. Procedure as prescription

Template analysis rejects prescribed procedures and can generate varied interpretations. There is no one precise way to conduct template analysis; the characteristics of template depend on many aspects, but most importantly to address the research question. In this study categories for template analysis span from two to five levels which encourages research to develop themes expansively where the richest data relevant to SCFP are found (Appendices 1; 2; 17; 18).

4. Too much flexibility

Template analysis invites the researcher to select what they feel is the most appropriate coding structure, with the option of using integrative themes and other literal connections between hierarchical clusters and the exhortation to code as many levels as are needed to generate the richest data. In this study, most detailed coding is found within areas which are both important to participants and relevant to the research question.

5. Limited guidance on the final interpretation

Template analysis gives loose guidance on how to move from the point where all data are coded to the final interpretation. This can lead researchers to simply summarise what they have coded under each theme. However, this study has further engaged in more sophisticated and interpretative thinking.

On the other hand, the flexibility and adaptability of template are utilised as important strengths rather than limitations in this study. King and Brooks (2017) highlighted key strengths and opportunities for template analysis, which this study explored to achieve objectives, 3, 5 and 6, and address the research question successfully. These strengths include adaptability, balancing openness and structure, efficiency and transparency:

1. Adaptability

A strength of template analysis as a style of thematic analysis is its adaptability, especially for pragmatic management research. Template analysis enables a researcher to tailor codes, themes and template techniques to the needs of a particular study. This ensures that analysis is coherent with a researcher's philosophical and theoretical approach, and its application to the real world. A similar process enables this study to generate initial templates based on sub-sets of data, which was iteratively developed to build final theoretical and empirical templates of SCFP.

2. Balancing openness and structure

The flexibility of template analysis helps to achieve a balance between openness and structure in coding. The relatively non-prescriptive approach to how the template should be organised encourages the researcher to retain an open-minded approach to the analysis. This improves the quality of this study in light of new data or modifying previously coded data to reconfigure hierarchical clusters of themes, which provides a systematic basis for analysis.

3. Efficiency

The front-loading of analytical work in template analysis results in a more efficient use of time across the analysis as a whole. In this study, thorough and detailed work was conducted to develop the initial templates, which enables subsequent coding and the development of the final templates to go quite smoothly.

4. Transparency

The development of coding templates from initial to final templates presents a high degree of transparency to the analytical process by showing records of how templates are iteratively developed (Appendices 1; 2; 17; 18). This process has auditability advantages for the analysis by a researcher, which is a significant aspect of quality assurance in qualitative analysis (Carcary, 2009).

4.9 Analytical hierarchy process

A major challenge facing decision-makers in different industries is to determine the relative importance of the evaluation criteria with respect to the overall objective (Elgazzar *et al.,* 2012). The intricate nature of human capacity to compare or to decide on multiple factors or alternatives makes the MCDM complex and challenging (Deng, 1999; Moneim, 2008). Several MCDM analysis methods have been proposed to deal with decision or selection problems (Matsatsinis and Samaras, 2001; Kuo *et al*., 2006). One of the most widely used approaches for MCDM is AHP (Saaty, 1980), which has its basis in obtaining the relative weights among factors and total values of each alternative based on these weights (Torfi *et al.,* 2010). In comparison with other MCDM methods, the

AHP method has been generally accepted as a MCDM technique and has been applied successfully in many practical decision-making problems (Alphonce, 1997; Saaty, 1988).

4.9.1 Fundamentals of analytical hierarchy process

AHP is a MCDM method that was originally developed by Saaty (1977) to determine the relative importance of a set of activities in a MCDM. AHP makes it possible to combine judgments on intangible qualitative criteria alongside tangible quantitative criteria (Badri, 2001). The AHP method is based on three principles, structure of the model, comparative judgment of the alternatives and the criteria, and synthesis of the priorities (Amiri 2010). AHP uses procedures for deriving weights and scores achieved by alternatives which are based on pairwise comparisons between criteria and between options (Rangone, 1996). The pair-wise comparisons are recognised as linguistic evaluations or assessments expressing the relative importance of pairs. The weight of each element in every hierarchical level are aggregated to the next level by applying the principle of hierarchic composition (Mikhailov, 2004).

Connecting NLNG supply chain strategies to financial objectives represents an opportunity for NLNG to gain competitive advantages by focusing on linking supply chain strategies and competences towards enhancing financial performance. There are several possible MCDM techniques to assist with this kind of analysis. Many approaches have been developed to aggregate the performance from multi-criteria expressions to handle hierarchical relationships and to quantify the weights and the performance expression (Berrah and Clivillé, 2007). AHP has the robustness to combine with other analytical methods to facilitate valuable conclusions for strategic decision-making. Elgazzar *et al.*

(2012) combined the SCOR model, Du Pont ratio analysis, Dempster-Shafer/AHP to propose a method that link supply chain performance metrics to the priorities of a company's financial performance; Brandenburg (2017) combined simulation and AHP to suggest a hybrid approach to configure an eco-efficient supply chain for a new product under consideration of economic and environmental risks. AHP is also an effective tool in logistics and SCM decision-making (Sipahi and Timor, 2010). Roh *et al.* (2015) combined AHP and fuzzy-TOPSIS methods to propose a multi-criteria decision framework for the pre-positioning of warehouses for humanitarian organisations. AHP has been effectively utilised to analyse international consolidation terminals, airports locations and determining what to benchmark (Partovi, 1994).

AHP methods were chosen for this study to analyse SCFP strategy of NLNG systems because the technique is particularly effective for multi-attribute decisions that involve both tangible and intangible factors (Alberto, 2000). The decision to use this technique was based on its ability to analyse several factors and gain a weight for each factor, to prioritise and optimise each of the four SCFP strategies in NLNG systems. Using AHP, the relative importance of individual criteria for SCFP was determined (Roh *et al.,* 2015)

4.9.2 Procedure for analytical hierarchy process

AHP requires strategic decision-makers to provide judgments regarding the relative importance of each criterion, and to specify preference for each decision alternative relative to each criterion (Saaty, 1980). The output of AHP is a prioritised ranking of the decision alternatives based on the overall preferences expressed by the decision-maker. This is achieved by setting priorities or weighing different alternatives based on pre-defined criteria to achieve a certain goal, which enables selection of best alternatives (Tramarico *et al.,* 2015).

AHP procedures involve six essential steps (Lee *et al.,* 2008), defining the unstructured problem, developing the AHP hierarchy, pairwise comparison, estimating the relative weights, checking the consistency, and obtaining the overall rating (Moshen *et al.,* 2010).

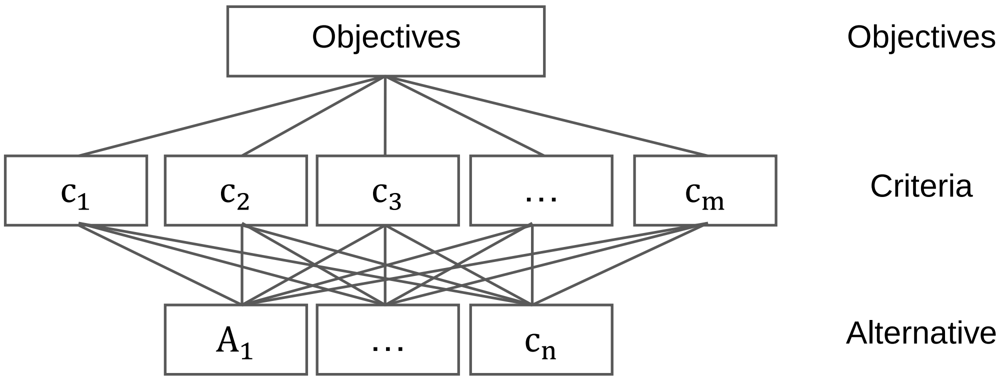
1. Define the unstructured problem

The unstructured problem and its characteristics should be recognised and the objectives and outcomes presented clearly (Moshen *et al.,* 2010). Due to the enormous challenges facing LNG operators and the global oil and gas industry at large (Chapter 2), the overarching objective of this study is to propose strategies and policies to improve SCFP in NLNG systems (Objective 5).

2. Developing the AHP hierarchy

The first step in the AHP procedure is to decompose the decision problem into a hierarchy consisting of the most important elements of the decision problem. A complex problem is decomposed into a hierarchical structure with decision elements (Moshen *et al.* 2010). AHP helps to breakdown a complex MCDM problem into a hierarchy of interrelated decision criteria and alternatives. A hierarchy has a minimum of three levels, overall goal of the problem, multiple criteria that define alternatives in the middle and decision alternatives at the bottom (Albayrak and Erensal, 2004; Amiri, 2010) (Figure 4.2). The survey participants specify judgements regarding the relative importance of each criterion in terms of its contribution to the achievement of the overall goal. At the final level, each participant indicates preference for each decision alternative (Saaty, 2003). Each decision maker is asked to express the relative importance of two decision elements in the same level by a nine-point scale (Figure 4.3; Appendix 5). Scores are collected to form pairwise comparison matrices for each of the decision makers (Lee *et al.* 2008). A mathematical process is used to synthesise the information on the relative importance of the criteria and preferences for the decision alternatives to provide an overall priority ranking of the decision alternatives (Saaty, 1994b).

Figure 4.2: Hierarchical structure of the decision problem



Source: Moshen *et al.* (2010:692)

3. Pairwise comparison

Pairwise comparison is a prioritisation procedure to determine the relative importance of the criteria within each level once the problem has been decomposed and the hierarchy is established. The pairwise judgment starts from the second level and ends at the lowest level. In each level, the criteria are compared pairwise according to their levels of influence and based on the specified criteria in the higher level (Albayrak and Erensal, 2004).

$$A = \begin{pmatrix} a_{11} & \cdots & a_{12} & \cdots & a_{1n} \\ \vdots & & \vdots & & \vdots \\ a_{21} & \cdots & a_{22} & \cdots & a_{2n} \\ \vdots & & \vdots & & \vdots \\ a_{n1} & \cdots & a_{n2} & \cdots & a_{nn} \end{pmatrix} \qquad a_{ii=1},\ a_{ji} = 1/\ a_{ij},\ a_{ij} \neq 0.$$

Let "$C_j\ j = 1, 2, \ldots, n$" be the set of criteria. The result of the pairwise comparison on *n* criteria can be summarised in an "n x n" evaluation matrix "A" in which every element $a_{ij}\,(ij = 1, 2, \ldots, n)$ is the quotient of weights of the criteria.

Experts can express their preference or importance pairwise between two factors using a scale of 1 to 9. Pairwise comparisons form the fundamental building block of AHP (Anderson *et al.,* 2009). AHP requires participant to state how important each criterion is relative to each other criterion when the criteria are compared two at a time, pairwise, to establish the priorities. In this study there are four criteria. In each comparison, participants must select the most important criterion and then express a judgement of how much more important the selected criterion is. Multiple pairwise comparisons are based on a standardised comparison scale of nine levels (Table 4.5).

Table 4.5: Scales for pairwise comparison

Preferences expressed in numeric variable	Preferences expressed in linguistic variable
1	Equally important
3	Slightly more important
5	Strongly more important
7	Demonstrably more important
9	Absolutely more important
2,4,6,8	Intermediate values between adjacent scale values
Reciprocals	If the activity *i* < > *0*when this is compared with the activity *j,* then *j* has a reciprocal value when it is compared with $(a_{ij} = 1/a_{ij})$

Source: Adapted from Saaty (1980)

4. Estimating the relative weights

Arithmetical process commences to normalise and find the relative weights for each matrix. The relative weights are given by the right eigenvector (w) corresponding to the largest eigenvalue (λ_{max}).

$$A_w = \lambda_{max} w$$

Where:
λ_{max} is the maximum eigenvalue of A and the unit matrix;

w the eigenvector.

(Moshen *et al.,* 2010: 692; Ozyigit and Egi, 2012: 315).

5. Consistency checking

An important consideration in AHP is consistency of pairwise judgements provided by the participants or decision-makers. For instance, if criterion A compared to criterion B has a numerical rating of 3 and criterion B compared to criterion C has a numerical rating of 2, perfect consistency of criterion A compared to criterion C would have a numerical rating of 3 x 2 = 6. If the A to C numerical rating assigned by the survey participant were 4 or 5, some inconsistency would exist among the pairwise comparisons (Jayawickrama, 2015). Perfect consistency is difficult to achieve with numerous pairwise comparisons, some degree of inconsistency can be expected to exist in almost any set of pairwise comparisons (Jayawickrama, 2015).

AHP provides a method for measuring the degree of consistency among the pairwise comparisons provided by the participant to handle the consistency issue (Wang and Yang, 2007). Consistency of the matrices is checked to ensure that the judgments of decision-makers are consistent (Moshen *et al.,* 2010). If the pairwise comparisons are consistent then A has rank 1 and $\lambda_{max} = n$. In this case, weights can be obtained by normalising any of the rows or columns of A (Wang and Yang, 2007). AHP must meet the requirement that matrix A is consistent. The consistency is the relation between the entries of A: a_{ij} x $a_{jk} = a_{ik}$.

$$\text{CI} = (\lambda_{max} - n)/(n - 1)$$

Lee *et al.* (2008: 101)

Unlike CI, Consistency Ratio (CR) enables researchers to determine whether the evaluations are sufficiently consistent. CR is the ratio of CI and the Random Index (RI). The RI shows the random inconsistency index for matrices in the order from 1 to 10 (Saaty and Kearns, 1985) (Table 4.6).

$$\text{CR} = \text{CI/RI}$$

Lee *et al.* (2008: 101)

Table 4.6: Random index (RI)

Number of Criteria	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Source: Moshen *et al.* (2010: 692)

Decisions are considered to be consistent if CR < 0.1. Only consistent weights can be considered in the ranking process. The evaluation procedure has to be repeated to improve consistency if the final CR > 0.1 (Saaty, 1980). The measurement of consistency can be used to evaluate the consistency of decision-makers as well as the consistency of the overall hierarchy (Wang and Yang 2007). In general CR <= 10% is usually considered acceptable and then the derived weights may be used (Mohsen *et al.,* 2010).

6. *Obtaining the overall rating*

Finally, relative weights of the decision elements are aggregated to obtain an overall rating for the alternatives (Moshen *et al.* 2010).

$$w_i^s = \sum_{j=1}^{m} w_{ij}^s \, w_j^a \qquad (i = 1, 2, \dots, m)$$

Where:
w_i^s is the total weight of alternative i;

w_{ij}^s the weight of alternative i associated to attribute j;

w_j^a the weight of attribute j;

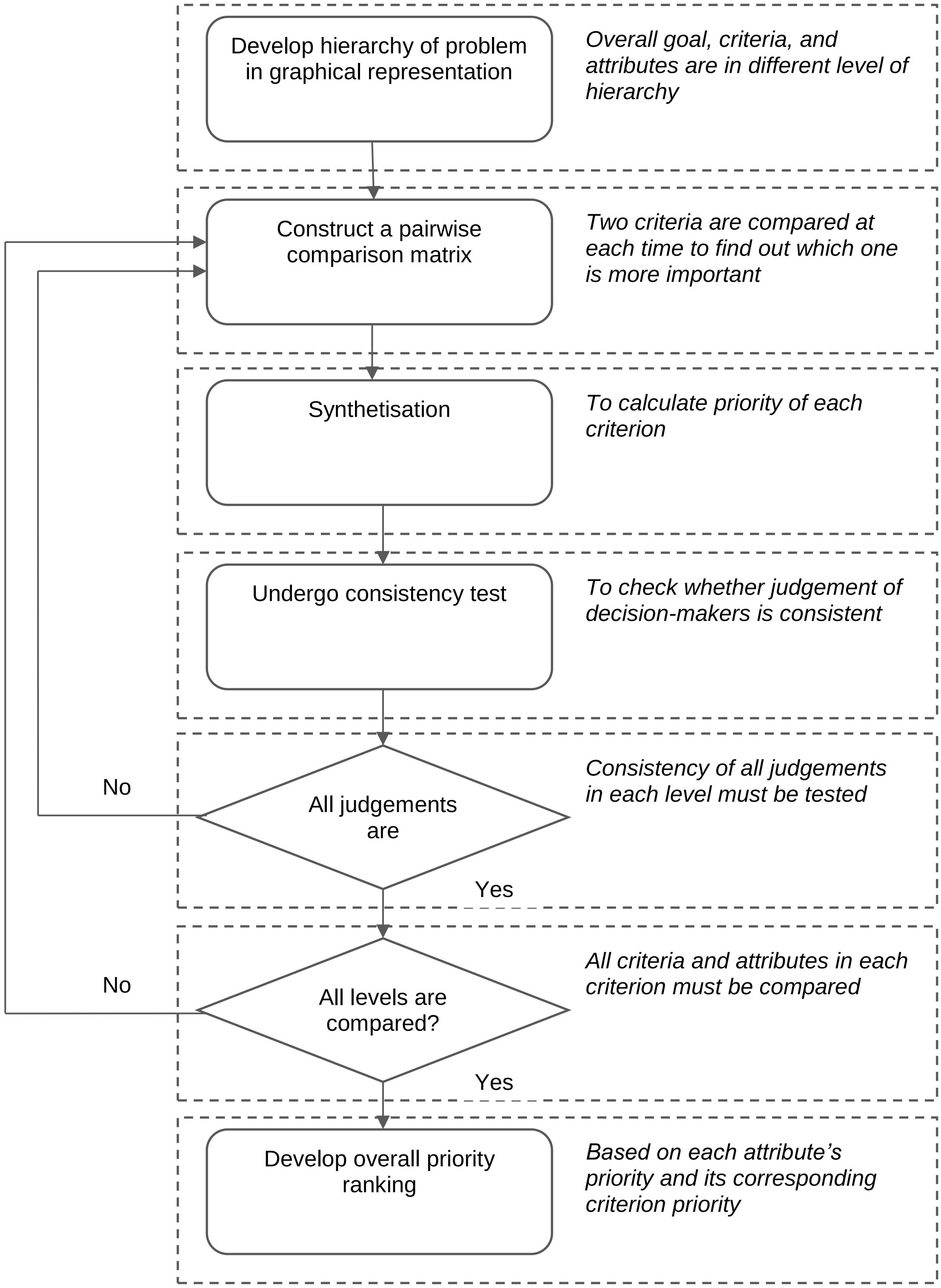
m the number of attributes;

n the number of alternatives.

Flow of analytical hierarchy process

The AHP consists of three main activities which are hierarchy construction, priority analysis, and consistency verification. The decision-makers need to breakdown complex MCDM into components. Every possible attribute should be arranged into multiple hierarchical levels. The decision-makers must compare each cluster in the same level in a pairwise approach based on individual experience and knowledge. Since the comparisons are carried out through personal or subjective judgements, some degree of inconsistency may occur. Consistency verification is carried out to guarantee that the judgements are consistent. Consistency verification is regarded as a major strength of AHP, is incorporated to measure the degree of consistency among the pairwise comparisons through CR computation. If it is found that CR > 0.1, the decision-makers should review and revise the pairwise comparisons. Once pairwise comparisons are carried out at every level, and are proved to be consistent, the judgements can then be synthesised to find out the priority ranking of each criterion and its attributes. Ho *et al.* (2006) presented a flowchart which demonstrates AHP procedure (Figure 4.3).

Figure 4.3: The flowchart of analytical hierarchy process



Source: Ho *et al.* (2006: 327)

4.9.3 Group decision-making in analytical hierarchy process

Many organisations employ groups in decision-making problems and because of the growing complexity in the socio-economic environments, it is difficult for individual decision-makers to consider all of the relevant aspects of a given problem (Ahn, 2000). The migration from a single decision-maker setting to a group decision-making set-up introduces complexity into MCDM analysis, because all the processes for a single decision-maker have to be performed for multiple participants (Roh, 2012).

AHP allows group decision-making where decision-makers can use their experience and knowledge to make decisions in a hierarchy, placing the overall objective of the decision at the top of the hierarchy, followed by criteria and decision alternatives in descending order. Once the group is satisfied with the problem structure, pairwise comparisons are conducted for each level of the hierarchy to obtain the weights with respect to elements in the higher level (Harker and Vargas, 1987). Kim and Ahn (1997) posit that the problem of group decision making under multiple criteria shares some common characteristics which are outlined in the below:

1. *Multi-criteria/objectives/alternatives*

Each problem has multiple criteria/objectives/attributes. The other decision-makers may share some, none or all of the decision-making criteria/objectives/alternatives.

2. *Conflict among criteria*

Multiple criteria usually conflict with each other. For example, in designing a car, the objective of size might reduce the passengers' comfort because of less space.

3. Committee

A group of decision-makers whose actions or decisions agree with certain rules that further their interests.

4. Alternatives

There are finite number of alternatives that each group member can choose from.

Where the individual preference of the group of decision-makers are collected, a method of combining or aggregating the opinions is required. There are two methods for aggregating individual decisions into group decision-making. First, “aggregating individual weight values” which involves collection of each individual’s hierarchies and aggregation of the resulting weights or values (Kim and Ahn, 1997; Forman and Peniwati, 1998; Bolloju, 2001; Zahir, 1999). Second, “aggregating individual judgements” which involves compilation of the pairwise comparison matrices at each level of a hierarchy by aggregating all the decision-makers individual judgements (Bolloju, 2001; Forman and Peniwati, 1998; Zahir, 1999).

There are two main methods for generating group priorities in AHP, geometric mean (Saaty, 1989) and arithmetic mean (Ramanathan and Ganesh, 1995) for synthesising the individual judgements. The advantage of using the geometric mean method for generating the elements of the matrix is that it preserves the reciprocal property n of the combined pairwise comparison matrix (Aczel and Saaty, 1983; Chwolka and Raith, 2001). However, the geometric mean method has the disadvantage of not automatically guaranteeing Pareto optimality when there are more than one levels in the decision hierarchy. Arithmetic mean method generates a Pareto optimal agreement for one issue, independent of the specific weights attached to the individual preferences (Chwolka and Raith, 2001). Both the geometric mean method and the arithmetic mean method are widely used to determine group judgement by aggregating individual priorities for ratio scale measurements (Forman and Peniwati, 1998; Bolloju, 2001).This study employed geometric mean approach to generate group priorities. Saaty (1989) argued for the geometric mean method of the individual judgements to obtain a group judgement for each pairwise comparison over the elements in the matrix, because it takes into account the compounding that occurs from one decision-maker to another.

Geometric mean, n^{th} root of the product of n numbers:

$$\left(\prod_{i=1}^{n} x_i\right)^{\frac{1}{n}} = \sqrt[n]{x_1 x_2 \cdots x_n}$$

Source: Saaty (1980)

4.9.4 Proposed analytical hierarchy process model

An AHP model (Moshen *et al.,* 2010) was utilised to link supply chain strategies to NLNG SCFP. According to the AHP model, the importance weight of the evaluation criteria is determined with respect to the priorities of related decision elements. Using the AHP model, the importance weights of SCFP measures are determined with respect to the priorities of the NLNG financial strategy. Consequently, supply chain strategy is formulated based on these priorities by channelling supply chain initiatives to towards enhancing the financial performance in NLNG systems.

The proposed AHP computation and model for optimising SCFP in NLNG consists of three basic stages: clearly identify the goal or objective, synthesise the criteria to be used in the model, and evaluate the alternatives to determine the final rank (Moshen *et al.,* 2010).

1. *Clear objective:*

In study phase one, an extensive review of industry literature was conducted which established that one of the major challenges facing NLNG, the LNG sector, and the oil and gas industry at large is facing insufficient investment due to financial squeeze (Chapter three). This study conducted a rigorous study which looked inward into NLNG supply chains in an effort to propose strategies and policies to optimise SCFP in NLNG. This study has established that improving SCFP in NLNG systems as its overarching objective, and placed it at the highest level of the AHP hierarchy (Moshen *et al.,* 2010; Ho *et al.,* 2006).

2. *Synthesise the criteria to be used in the model*

In study phase one, SCFP systematic literature review established four traditional financial performance measures, *revenue growth, cost reduction, working capital efficiency,* and *fixed asset utilisation* as criteria for evaluation of SCFP. These four constructs form the second level in the AHP hierarchy (Moshen *et al.,* 2010).

3. *Evaluation of alternatives*

The bottom of the AHP hierarchy (Moshen *et al.,* 2010) saw *sourcing strategy, IT and automation, integration and collaboration*, and *sustainability* presented as the decision alternatives (Study phase one).

The AHP model is structured so that objective is in the first level, criteria are in the second level and alternative locations are on the third level (Saaty, 1989) (Figure 4.2). Due to the size and complexity of LNG operations, a group decision-making approach was adopted for NLNG as a whole and key divisions responsible for supply chain strategic decisions that impact financial performance. Group decision-making method is widely adopted in AHP studies where the participants are in the managerial level and have better insights of the problem and have actual influence in the decision making process (Amiri, 2010; Kuo *et al.* 2007). AHP is one available method for forming a systematic framework for group interaction and group decision-making (Saaty, 1980).

After establishing a decision hierarchy, the next step involved assigning weights to SCFP measuring criteria using pairwise matrixes. The identified experts responsible for supply chain decision-making at relevant divisions of NLNG made individual evaluations using the bi-polar scale provided in the questionnaire (Figures 4.3; 4.5; Appendix 5) to determine the values of the elements of pairwise comparison matrixes. Calculating the geometric mean of the values obtained from individual pairwise comparison matrices for decision criteria and alternatives, final pairwise comparison matrices were established from which consensus was found. Geometric means of these values are found to avoid error and to obtain a pairwise comparison matrix which is consistent (Saaty, 1989); when CR <=0.1, the judgement would be used in the ranking process because it is regarded as consistent. The measurement of consistency can be used to evaluate the consistency of decision-maker as well as the consistency of overall group (Wang and Yang, 2007).

4.9.5 Conducting AHP using spreadsheets

AHP analysis involves complex mathematics, and it is very challenging to perform manually without making errors, especially when dealing with large number of decision criteria, alternatives and participants (Jayawickrama, 2015; Ho, 2008;

Subramanian and Ramanathan, 2012). Over the years, different software tools were developed to perform the AHP analysis such as AHP Online System – BPMSG, Priority Estimation Tool, AHP Online Calculator, Make it Rational AHP software and Expert Choice (Ishizaka and Labib, 2009). However, similar to Roh *et al.* (2015) Microsoft Excel spreadsheet was selected and used over the other fully software tools for this study mainly because its hybrid characteristic, it combines both manual input of data and formulas, as well as automatic processing and results presentation. Microsoft Excel helps in addressing reliability issues, because it is user friendly and users can always verify, review or query any part of the AHP analysis process within seconds. A downside of using Excel is due to its semi-automated feature, unlike web-based fully automated solutions like Expert Choice software that is completely integrated, where survey participants can see the inconsistency ratio of a particular matrix on the screen when providing pairwise responses, enabling respondents to revise the judgements if the inconsistency ratio is greater than 0.1. Using excel spreadsheet for AHP also support discussion, because it enables users to know what is going on at every stage of the calculation, unlike the fully automated software where most of the calculation is running in the back end (Ishizaka and Labib, 2009; Saaty and Vargas, 2012b).

4.9.6 Strengths and weaknesses of analytical hierarchy process

There are certain strengths for using AHP to analyse SCFP in NLNG systems. The pairwise comparison questionnaire is user-friendly and data input is straightforward and convenient (Alphonce, 1997; Yoon and Hwang, 1995). AHP has the ability to handle complex real life problems (Alphonce, 1997). Narasimhan (1983) and Alberto (2000) presented three advantages of AHP. First, AHP is versatile and is employed in a wide range of applications, including forecasting because AHP allows for judgment regarding the relative likelihood of events to be made. Second, AHP prescribed structuring of problems allows complex decisions to be decomposed into sets of simpler judgments and provides a rationale for the choice of a particular option. Third, it is simple because the use of pairwise comparisons implies that the decision-maker can focus on a sub-set of a given problem at a particular time.

AHP facilitates better communication, leading to a clearer understanding and consensus among members of decision-making groups so that they are likely to become more committed to the alternatives selected (Harker and Vargas, 1987). AHP also has the ability to identify and take into consideration the decision-maker's personal inconsistencies. Decision-makers are rarely consistent in their judgements with respect to qualitative aspects. The AHP method incorporates such inconsistencies into the model and provides the decision-maker with a measure of these inconsistencies (Alphonce, 1997).

Since the introduction of AHP in 1977, there has been widespread criticism of its empirical effectiveness and theoretical validity. Questions are raised regarding AHP's axiomatic foundation, inconsistencies imposed by scale of 1 to 9, and rank reversal problem due to addition or deletion of alternatives (Belton and Gear, 1983; Dyer, 1990a, 1990b). In respect of axiomatic foundation, the clarity and intuitive meaning of set of rules which are intended to provide the basis for rational decision-making, are not founded on testable descriptions of rational behaviour. Saaty (1980) has given a sound but incomplete axiomatic foundation for AHP, which focuses mostly on paired comparisons among alternatives within criteria, however, the interdependence between alternatives and criteria and among criteria across levels remains ambiguous. Inconsistencies imposed by scale of one to nine have been overcome in this study by introducing the consistency index. The rank reversal problem due to addition or deletion of alternatives arises from the way in which the AHP normalises the weights to sum to one and by multiplying inappropriate criteria priorities with priorities for alternatives (Lai, 1995). However, there is a further scaling method which is able to treat judgments from pairwise comparisons among criteria into values scales (Roh, 2012). The new integrated approach combines the main advantages of the data collection and treatment with the axiomatic foundation and the elimination of the rank reversal problem. It is argued that rank reversal is not a problem in real world applications because it is very rare to encounter two alternatives with very similar characteristics. In addition, special precautions such as grouping similar alternatives can easily be employed to avoid any rank reversal (Saaty, 1994b). Saaty (1994a) identified three steps for rank preservation: allow rank to reverse by using the distributive model of the relative measurement; preserve rank by using the ideal mode, in case of irrelevant alternatives; and preserve rank absolutely by using the absolute measurement mode. In this study, no single alternative or criterion was added or deleted after data was collected, which addressed the rank reversal issue entirely.

4.10 Rationale for combining AHP and template analysis

The combining of template analysis and AHP enabled this study to systematically analyse qualitative data gathered in studies phase one and three, as well as quantitative data collected in study phase two (Table 4.1).

Linking supply chain strategies to NLNG financial objectives represents an opportunity to gain competitive advantages by focusing on key supply chain strategies that enhance financial performance. Literature reviews revealed ambiguity and discrepancies in terms of the relationship between SCM practices and financial performance and how to measure this relationship is still not clear. A majority of studies on SCFP did not show links between supply chain performance and financial performance, and some studies present disjointed findings. A common drawback in SCFP studies is that they do not describe how SCFP is measured in detail, which makes the assessment of results difficult. This leads to the need for an applied methodology linking SCM strategies to a company's financial objectives.

In study phase one, qualitative template analysis was employed to analyse relevant literature texts. The final theoretical template (Appendix 2) helped in establishing the constructs of SCFP deductively presenting *sourcing strategy*, *IT and automation*, *integration and collaboration*, and *sustainability* as supply chain practices that enhance financial performance. Template analysis findings also presented traditional financial performance measures of *revenue growth, cost reduction, working capital efficiency,* and *fixed asset utilisation* as measures for SCFP. However, these are results from systematic literature review that are not tested in industry empirically. Results of template analysis fit well with AHP as a quantitative MCDM technique. In a MCDM problem, many criteria and alternatives should be considered in decision-making. From the template analysis, higher-order themes for SCFP practices are deployed as decision alternatives and higher-order themes for SCFP measure are used as decision criteria with the ultimate goal of improving SCFP in NLNG systems.

Decision making under AHP has a finite number of alternatives that decision-makers can choose from (Kim and Ahn, 1997). To remove any bias arising from limiting the findings of this study to only the scope prescribed by systematic review of extant SCFP literature, this study went further to conduct interviews in study phase three by asking questions based on characteristics and objectives SCFP in NLNG systems identified in the review publications relevant to NLNG (Chapter 2). Interviews were conducted with experts at NLNG to acquire latent information specific to NLNG systems, which enhanced the quality of results and assisted towards proposing strategies and policies to improve SCFP in NLNG systems (Objective 6) which ultimately address the research question. The interviews are also analysed using template analysis.

The combination of AHP statistical analysis and qualitative template analysis helped to draw more information from more participants, facilitated rigour in analysis and helped in triangulation of qualitative and quantitative data to arrive at valid conclusions.

4.11 Writing of case study report

The main issue that should be considered when writing the case study report is to decide what is to be included in the report and what is to be left out (Elgazzar, 2013). There is no stereotypic form for writing a case study report, but three steps should be executed: identifying the audience for the report, setting the compositional structure, and following clearly defined procedures. Considering that different audiences have different needs and interests, the report's structure and contents will vary accordingly (Yin, 1994).

4.12 Ethical considerations

Shank (2006: 97) argued that a good researcher is an ethical researcher. This research involved human participants during empirical data collection, the relevant General Data Protection Regulation (GDPR, 2016) guidelines are followed and ethical approval was granted by the University of Plymouth Faculty of Business Research Ethics Committee on June 28, 2017 before commencing this research (Appendix 7). The application for ethical approval includes the research objectives, brief description of methods and procedures, respect for participants, and relevant training which will minimise risks to the participant, researcher and wider society. The researcher adhered to ethical protocol by communicating with the participants beforehand, describing the research agenda in the information sheet, which along with the consent form was sent to the respondents via the gatekeeper (Appendices 8; 9). In addition, a confidentiality agreement between NLNG and the researcher was signed on March 05, 2018 before the commencement of empirical data collection (Appendix 10). Targeted respondents who do not consent to take part were not approached to answer any of the questionnaires (Appendices 4; 5; 6). Any participants have the right to withdraw from the study at any time without giving any reason. An executive summary of empirical findings was made available to the participants through the gatekeeper (Appendices 16; 19). To avoid researcher’s bias, before the research is published, findings and conclusions are peer reviewed through a series of academic disseminations.

4.13 Summary of chapter four

This chapter presented and analysed the methodology, methods, models and techniques which are employed by this study to build a taxonomy and a framework of SCFP in NLNG networks. Template analysis (King and Brooks, 2010; Brooks *et al*., 2015) was employed due to its appropriateness in addressing the research question to develop a generic taxonomy and a theoretical framework of SCFP in study phase one; and to build an explicit taxonomy and an empirical framework of SCFP in NLNG networks in study phase three. AHP (Saaty, 1980) was used as a suitable MCDM technique to measure the relative influences of various supply chain capabilities on financial performance in NLNG systems.

The process of conducting the case study has been discussed in detail, including how the case study was designed, how data were accessed, collected and analysed and presented. The procedures used in conducting this study across three research phases was discussed. The ethical considerations that underpin study of SCFP in NLNG systems are also discussed. The next two chapters provide detailed empirical analyses and discussions.

Chapter five: Quantitative analysis

5.1 Chapter five overview

This chapter analyses empirical quantitative surveys conducted in study phase two to access the SCFP capabilities in NLNG systems and to propose strategies and policies to improve SCFP in NLNG networks (Objectives 4; 6).

Study phase two prioritised the SCFP drivers and measures established in study phase one (Chapter 3) in NLNG systems using quantitative survey data collected from supply chain experts at NLNG. The prioritisation was conducted using AHP as a MCDM method to measure the relative weight of each of the identified SCFP drivers on NLNG's financial performance. Supplementary quantitative Likert-scale data was also analysed within the case study (Section 5.7) to evaluate the factors that influence SCFP capabilities in NLNG systems.

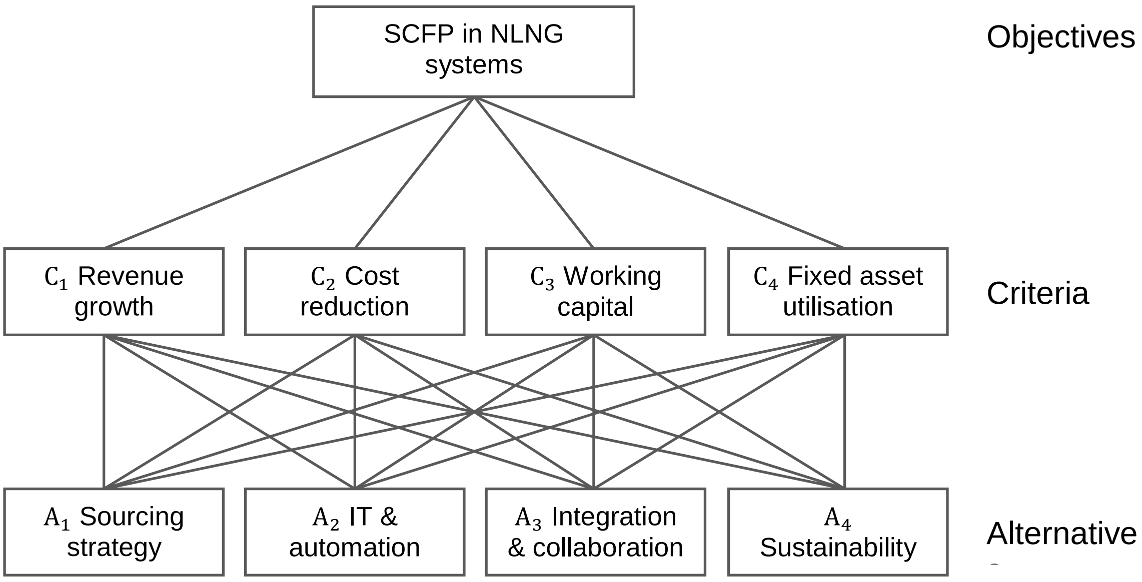
5.2 Study phase two: AHP in NNLG SCFP

In this section of the analysis, similar to the AHP analysis conducted by Roh *et al.* (2015), SCFP strategies identified in study phase one are evaluated to obtain their relative weight in NLNG supply chain systems based on expert opinion. The first step taken was to develop a hierarchy by breaking down the research problem into components. The three major levels of the hierarchy are the objective, the criteria and the alternatives (Mohsen *et al.,* 2010). The ultimate objective of this study is to propose strategies and policies to improve SCFP in NLNG systems (Objective 6). The second and the third steps in the process of improving SCFP in NLNG networks are establishing decision criteria and decision alternatives for supply chain strategies that have impact on financial performance. Study phase one findings revealed four measures for SCFP, $C = (C_1, C_2, C_3, C_4)$ which are utilised as criteria in a pairwise comparison matrix to determine ranking or the degree of influence of each criterion to SCFP in NLNG systems, where: C_1 *is revenue growth*; C_2 is *cost reduction*; C_3 is *working capital efficiency*; C_4 is *fixed asset utilisation*. Once the pairwise comparison matrices were formed, AHP was employed to determine the criterion weights using the eigenvector method (Section 4.9.2). The pairwise comparison matrix was established using a nine-point scale (Tables 4.3; 4.5; Appendix 5), and the weight for each criterion was determined using the eigenvector method.

Results from study phase one also suggested four drivers of SCFP, represented as A_1, A_2, A_3, A_4, which in study phase two are adopted as alternatives for paired comparison matrix of alternatives with respect to criteria (Figure 5.1), Where: A_1 is the *sourcing strategy*; A_2 is *IT and automation*; A_3 is *integration and collaboration*; A_4 is *sustainability*.

In the process of prioritising the drivers of SCFP in NLNG systems, each alternative is evaluated against the corresponding criterion based on experience and the subjective opinion of decision makers regarding NLNG SCFP. The weight of each alternative was then determined using the eigenvector method.

Figure 5.1: Conceptual model for optimising SCFP in NLNG systems



Source: Author

5.2.1 Group decision-making

This study utilised AHP as a methodology which was effective in eliciting judgment from professionals at NLNG who carry out decision-making responsibilities that have supply chain financial influences, in a systematic and consistent manner. AHP helps to obtain group consensus in a highly political environment in a timely manner to tackle a complex problem (Badri, 1999). Supply chain strategy is usually a product of team effort, and AHP is a method for developing a systematic framework for group interaction and group decision-making (Saaty, 1982). The group decision-making method is widely adopted in previous AHP studies where the participants are at managerial level and have good experience and insights of the problem and are experts who are involved in regular decision-making processes (Amiri, 2010; Ertuğrul, 2008; Kuo et al. 2007). The AHP hierarchical structure for this study was established deductively from the findings of study phase one (Figure 3.2; Appendix 1), which was subsequently shared, explained and approved by the supply chain decision-makers at NLNG through the gatekeeper (Section 3.8).

5.2.2 Identification and description of respondents

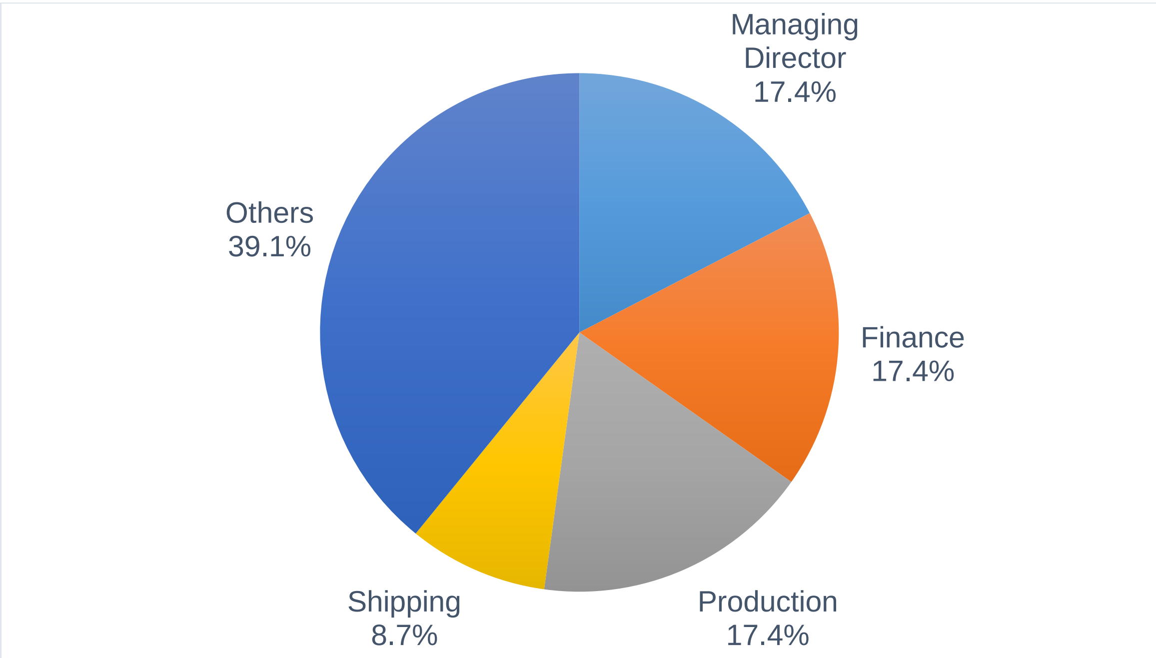
The researcher worked with two experts well acquainted with SCFP at NLNG and identified professionals at managerial level who are involved in supply chain strategy decision-making at NLNG. The participants' experience in NLNG SCM provided valuable information towards addressing the research question. Only one of the experts stated less than five years SCM experience at NLNG, with one of the participants having less than ten years of NLNG SCM experience. This demonstrates the richness of the data set with a high level of understanding and experience of the participants in supply chain strategic decision-making at NLNG systems. It can be stated that 100% of the participants have been involved with supply chain strategies that have influences on NLNG financial performance for at least four years.

5.2.3 Response rate

It was extremely difficult to obtain complete responses from the target professionals at NLNG, since they are very engaged with their demanding work responsibilities. After the initial contact through the gatekeeper and subsequent email invitations to undertake the study, four reminders were sent as follow-ups to obtain complete responses. However, despite the challenges encountered during data collection, a considerable amount of data was collected and reached a satisfactory level of effective response rate of 72%. A total of 23 out of the targeted 32 experts responded in just over three months, between March 2018 and June 2018. All responses were considered for group decision analysis and the majority for sub-group or divisional analysis, depending on the number of respondents from a given division and the relevance of the division to NLNG SCFP.

The 23 decision-makers who responded are from a wide range of managerial levels across nine diverse business divisions involved with strategic supply chain decision-making that has financial influences for NLNG supply chains. The respondents' profiles were analysed with the objective of determining the role they play in NLNG SCF. Individual responses were grouped together for analysis. In addition, responses were also analysed collectively for key divisions that make decisions pertinent to SCFP in NLNG as sub-groups. Four sub-groups were identified made up of four respondents each from MD, Finance, and Production divisions, and two respondents from the Shipping division respectively (Figure 5.2).

Figure 5.2: Respondents divisions at NLNG



Source: Author

5.2.4 Group inconsistencies

The inconsistency ratios of group decision-making and for all the four key divisions involved in SCFP in NLNG are within the threshold of ≤ 0.1, consequently, all judgements can be accepted in the respective groups and the priorities calculated using these judgements (Saaty and Vargas, 2012a). All groups' inconsistency ratios are ≤ 0.05, excepting the Finance division which has the highest inconsistency ratio of 0.0690 (Table 5.1). The inconsistency ratio was derived by calculating the geometric mean, the n^{th} root of the product of n numbers (Section 4.9.2).

5.2.5 Criteria weights

The overall results for SCFP in NLNG measurement criteria were analysed. The weights of the attribution were calculated by geometric mean to obtain the pairwise comparison matrix in which consensus was found. The weights for decision criteria were obtained by applying the geometric mean principle to the relevant steps of the AHP procedure (Section 4.9.2).

5.2.6 Paired comparison matrix of alternatives with respect to criteria

The NLNG decision-making group and sub-groups' computation of a pairwise comparison matrix for criteria or SCFP measures against alternatives or SCFP drivers in NLNG systems, are consistent. Table 5.1 indicates the NLNG group decision consisting of λ_{max}, CI, RI, and CR. Overall CI = 0.0139 (0.250/1.8000) (Table 5.1). Detailed consistency calculations for NLNG decision-making group and sub-groups are presented as Appendices 10; 11; 13; 14; 15.

Table 5.1: Consistency of NLNG group decision-making

Criteria	λ_{max}	CI	RI	CR
Pairwise matrix	4.0362	0.0121	0.9000	0.0134
C_1	4.0759	0.0253	0.9000	0.0281
C_2	4.0310	0.0103	0.9000	0.0115
C_3	4.0083	0.0028	0.9000	0.0031
C_4	4.0175	0.0058	0.9000	0.0065
Overall		0.0250	1.8000	0.0139

Source: Author

Based on the consistencies for NLNG group decision-making (Table 5.1), the entire CR of the pairwise matrix for all criteria calculated is 0.0134. This established that the weights are said to be consistent and acceptable to be used in the selection process (Saaty, 1980). The CR for the overall weighted average rating is also 0.0139 (Appendix 11), which is within the acceptable inconsistency threshold of ≤ 0.1.

5.3 AHP findings for overall group results for SCFP criteria

Findings revealed *revenue growth* (C_1) with a normalized weight of 0.3206 as the most important factor for consideration when measuring SCFP in NLNG systems. *Cost reduction* (C_2) has a normalised weight of 0.3013 and is the second most important criteria for measuring SCFP in NLNG networks. Cumulatively, C_1 and C_2 have a normalised weight of 0.6219, representing over 62% of the SCFP measuring criteria in NLNG supply chains. The third ranked criteria for measuring SCFP in NLNG is *fixed asset utilisation* (C_4), which has a normalised weight of 0.2025, increasing the accumulated weight to 0.8244 or 82%. *Working capital efficiency* (C_3) was ranked as the fourth and considered as the least important

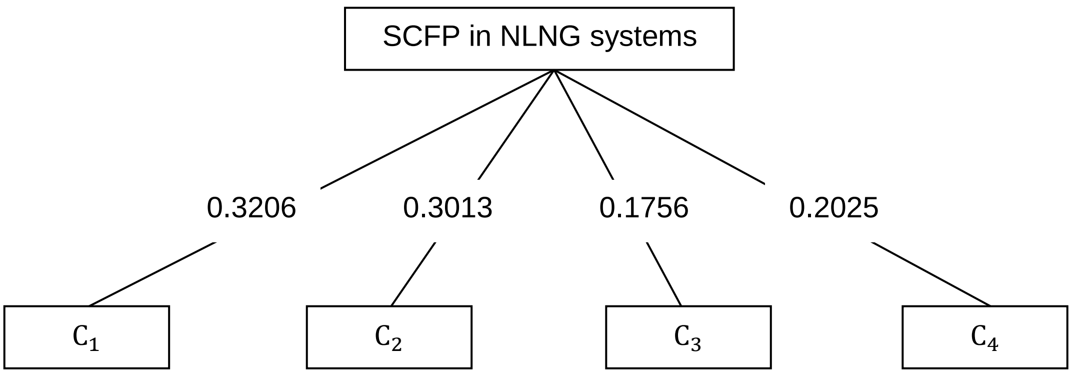
SCFP measurement criteria for by experts at NLNG, with a normalised weight of 0.1756 (Table 5.2; Figure 5.3; Appendix 11).

Table 5.2: Order of preference for SCFP measures in NLNG systems

Priority	Criteria	Normalised weight	Accumulated weight
1st	Revenue growth (C_1)	0.3206	0.3206
2nd	Cost reduction (C_2)	0.3013	0.6219
3rd	Fixed asset utilisation (C_4)	0.2025	0.8244
4th	Working capital efficiency (C_3)	0.1756	1.0000
	Total weight	1.0000	

Source: Author

Figure 5.3: Model for SCFP measures in NLNG systems



Source: Author

5.4 Evaluation of alternatives and determination final ranking

Decisions contain many intangibles that need to be traded-off, such as the SCFP drivers established in study phase one. To do that, they are measured alongside tangibles, which for this study are the traditional financial performance measures analysed (Table 5.2), whose measurements must also be evaluated as to how well they serve the desired objectives, which for this study are about proposing strategies and policies to improve SCFP in NLNG systems (Saaty, 2008). Data collected from experts at NLNG relevant to the four SCFP drivers identified in study phase one are utilised in this section as alternatives for SCFP in NLNG networks (Figure 5.1). NLNG group and sub-groups decisions on these alternatives are evaluated in a paired comparison matrix against the criteria weights calculated using AHP protocols to develop the preference for each decision alternative against each of NLNG's SCFP criterion (Tables 5.3; 5.4; Figure 5.4; Appendix 11). The AHP hierarchical process of analysis enabled this study to prioritise NLNG SCFP drivers accordingly.

Table 5.3: Group preference for SCFP in NLNG systems

	C_1	C_2	C_3	C_4	Composite weight	Priority
Criteria weight	0.3206	0.3013	0.1756	0.2025		
A_3	0.3142	0.3155	0.2605	0.2352	0.2892	1st
A_1	0.2705	0.2901	0.2992	0.2282	0.2729	2nd
A_2	0.1906	0.2174	0.2258	0.2916	0.2253	3rd
A_4	0.2247	0.1770	0.2145	0.2451	0.2127	4th
Total weight	1.0000		1.0000		1.0000	

Source: Author

NLNG's group decision composite weight of each SCFP driver was calculated by multiplying the priority vector/average of each alternative against its corresponding criterion average.

5.4.1 Iintegration and collaboration ranking in NLNG SCFP

Amongst the SCFP drivers, A_3 was accorded the highest priority by practitioners at NLNG, with a composite weight of 0.2892. The highest preference given to A_3 arose from its strong priority vector against top ranking SCFP measures, C_1 and C_2. Findings indicated that A_3 has the highest ranking of 0.3142 and 0.3155 impact on C_1 and C_2 respectively. This inferred that *integration and collaboration* strategies have an influence of over 31% on *revenue growth* and *cost reduction* in NLNG supply chain system. Additionally, results established that A_3 has the second strongest influence on C_3 with a weight of 0.2605, which makes *integration and collaboration* strategies major priorities for NLNG to attain financial performance in terms of its influence on *working* capital efficiency. Further findings revealed that A_3 was only ranked third by experts at NLNG with 0.2352 about its relationship with C_4. This suggests that *integration and collaboration* ranks lower in terms of its impact on NLNG *fixed utilisation* when compared to *IT and automation*, and *sustainable* supply chain strategies.

Empirical results corroborated the findings of study phase one where *integration and collaboration* was the dominant driver of SCFP. *Integration and collaboration* is the highest-ranking SCFP capability in NLNG due to its superior ranking in terms of its influence on *revenue growth* and *cost reduction*, as well as a very good ranking in relation to *working capital efficiency* as measures for financial performance.

Further analysis also revealed that the favourable ranking given to *integration and collaboration* was strongly influenced by the strongest preference given to this alternative by group decision-makers from the Shipping division, with a composite weight of 0.4738 (Table 5.8). This denotes that over 47% priority was accorded *integration and collaboration* by the Shipping sub-group. In addition, *integration and collaboration* is not the highest-ranked alternative from the MD, Finance, and Production divisions; however, it was ranked second by decision-making sub-groups from these three divisions. This explains the reason why the bigger NLNG group regarded *integration and collaboration* as a prime driver of SCFP.

5.4.2 Supply chain sourcing strategy ranking in NLNG SCFP

Findings revealed A_1 as the second ranked SCFP driver in NLNG, with a composite weight of 0.2729, which is just 1.63% lower than A_3 in the overall ranking. The high preference given to A_1 resulted from its strong priority vector against top ranking SCFP measures, C_1 and C_2. Results revealed that A_1 has the second highest ranking of 0.2705 and 0.2901 to C_1 and C_2 respectively. This implied that *sourcing strategy* has an impact of over 27% on *revenue growth* and an influence of over 29% on *cost reduction* in NLNG supply chain systems. In addition, findings established that A_1 has the highest influence on C_3 with a weight of 0.2992, which makes *sourcing strategy* a top priority for NLNG to attain financial performance in terms of its impact on *working capital efficiency.* However, relatively, the high priority given to *sourcing strategy* with regard to *working capital efficiency* does not have as much influence on its priority vector due to the very low rank of *working capital* efficiency as a measure for financial performance measure in NLNG systems (Table 5.2; Figure 5.3; Appendix 11). Further results revealed that A_1 has the least experts' ranking of with 0.2282 about its relationship with C_4. This implied that *sourcing strategy* has the lowest ranking in terms of its impact on NLNG fixed utilisation when compared to other SCFP drivers in NLNG proposed by study phase one.

Empirical NLNG case study results contradicted the results of study phase one where *sourcing strategy* is not as dominant as *IT and automation*, owing to the role of *IT and automation* as an enabler for *integration and collaboration*, which was the dominant driver of SCFP. *Sourcing strategy* is the second highest-ranking SCFP capability in NLNG due to its superior ranking concerning *working* *capital efficiency*, as well as a very good ranking in terms of its influence on *revenue growth* and *cost reduction* as financial performance measures.

Analysis also revealed that the second ranking given to *sourcing strategy* was highly influenced by the strongest preference given to this alternative by group decision-makers from MD, Production and Finance divisions. Especially results from the Finance division revealed a composite weight of 0.4197 to *sourcing strategy* as a driver of SCFP in NLNG (Table 5.7). This means that 41.97% priority was accorded *sourcing strategy* by the Finance sub-group. Moreover, results revealed that the reason *sourcing strategy* was not the number one driver of SCFP in NLNG was strongly associated with the favourable ranking given to *integration and collaboration* by group decision-makers from the Shipping division (Table 5.8).

5.4.3 Supply chain IT and automation ranking in NLNG SCFP

A_2 as a driver of SCFP in NLNG was ranked third by experts at NLNG, with a composite weight of 0.2253. Although A_2 was ranked third, it was still higher than A_4, largely due to its strong priority vector in relation to the third ranking SCFP measure, $\mathbf{C_4}$. Findings show that A_2 has the highest ranking of 0.2916 in relation to C_4. This implied that *IT and automation* strategies have over 29% influence each on *fixed asset efficiency* in NLNG supply chain system. Additionally, results established that A_2 was ranked third in terms of its influence on C_2 and C_3, with 0.2174 and 0.2258 respectively, which makes *IT and automation* strategy the third ranking priority to attain financial performance in terms of *cost reduction* and *working capital efficiency* in NLNG supply chains. Further findings revealed that A_2 was the least ranked criteria by experts at NLNG with 0.1906 in terms of its relationship with C_1. This inferred that *IT and* *automation* has the lowest ranking in terms of NLNG *revenue growth* compared to other SCFP drivers in NLNG systems proposed by study phase one.

Upholding findings in terms of *sourcing strategy*, empirical NLNG case study results refuted the results of study phase one where *IT and automation* is more dominant than *sourcing strategy*, owing to the role of *IT and automation* as an enabler for *integration and collaboration*, which was the dominant driver of SCFP. In the case of NLNG supply chains, *IT and automation* is the third ranking SCFP capability in NLNG due to the superiority of *sourcing strategy* concerning *revenue growth, cost reduction* and *working capital efficiency* as measures for financial performance.

Further analysis has also shown that it was only the ranking by the Finance sub-group that conforms to the ranking by the NLNG group decision makers with respect to *IT and automation* as a driver of SCFP in NLNG systems. Although the Shipping division rankled *IT and automation* higher in second position, it was offset by the least ranking given from MD and Production divisions (Tables 5.5; 5.6; 5.7; 5.8; 5.9).

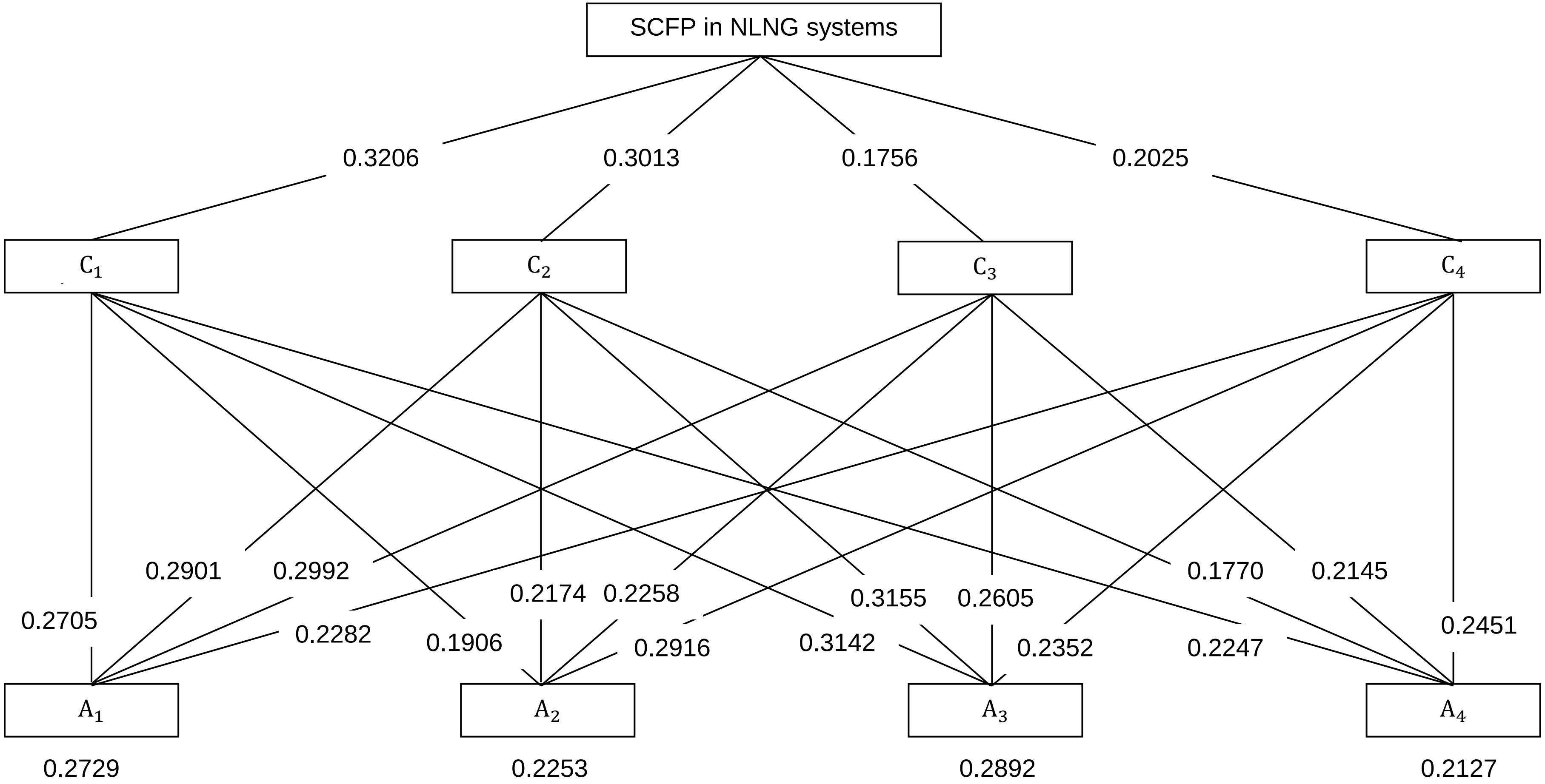
5.4.4 Supply chain sustainability ranking in NLNG SCFP

Amongst the SCFP drivers, A_4 was given the least priority by practitioners at NLNG, with a composite weight of 0.2127. The lowest preference accorded to A_4 was because it has the least priority vector in relation to C_2 and C_3 as SCFP measures. Findings have shown that A_4 has the lowest ranking of 0.1170 and 0.2145 impact on C_2 and C_3 respectively. This inferred that supply chain *sustainability* strategy has influence of only 17.7% and 21.5% on *cost reduction* and *working capital efficiency* in NLNG supply chain system. Additionally, results established that A_4 has the third ranking influence on C_1 with a weight of 0.2247, which makes *sustainability* strategy a minor priority for NLNG to attain financial performance in terms of its influence on *revenue growth*. However, further findings revealed that A_4 was ranked second by experts at NLNG with 0.2451 concerning its relationship with C_4. This indicates that supply chain *sustainability* strategy has the highest impact on NLNG SCFP in terms of fixed utilisation, which is only bettered by supply chain *integration and collaboration*.

Empirical results conformed to the findings of study phase one where *sustainability* was the least dominant driver of SCFP. *Sustainability* is the lowest ranking SCFP driver in NLNG systems due to its poor ranking in terms of its influence on *revenue growth, cost reduction* and *working capital utilisation* as financial performance measures.

Despite *sustainability* being ranked last by the NLNG group decision-makers, MD, Production and Shipping Divisions ranked *sustainability* in NLNG supply chain as third. This was not surprising considering *sustainability* is at the core of NLNG mission and vision statements. Further non-compliance with *sustainability* dimensions can result in huge *costs* to NLNG supply chains or even damage some of its asset or caused a shutdown in the supply chains, which is a major concern for Production and Shipping Divisions. LNG shipping is a value chain that is highly regulated due to environmental concerns such as pollution; social concerns such as welfare of crew; and economical concerns including loss of cargo, loss of vessel and fines.

Figure 5.4: Group decision model for SCFP in NLNG systems



Source: Author

The above AHP analysis (Figure 5.4) was based on a group response of 23 key decision-makers from a wide range of managerial positions across nine distinct business divisions involved with strategic supply chain decision-making that has financial implications for NLNG supply chains. Pairwise group decision-making by target respondents at NLNG ranked SCFP measurement criteria as follows: first – *revenue growth*; second – *cost reduction*; third – *fixed asset utilisation*; and last – *working capital efficiency*. In the same way, paired comparison of alternatives with respect to criteria revealed the final group ranking for SCFP drivers in NLNG as follows: first – *integration and collaboration*; second – *sourcing strategy*; third – *IT and automation*; and last – *sustainability*.

To facilitate in-depth assessment of the SCFP capabilities in NLNG systems and to propose strategies and policies that will improve SCFP in NLNG, study phase two went further to analyse decision-making by key divisions relevant to SCFP in NLNG as sub-groups using the same AHP protocols as employed for the main NLNG group analysis.

5.5 Divisional comparative results for SCFP criteria

Sub-groups analyses compared the order preference for SCFP criteria from divisional groups' perspective. These are MD, Finance, Production, and Shipping divisions respectively (Table 5.1; Figure 5.2).

Finance and Production divisions' preference are consistent with the group decision ranking for SCFP measures in NLNG, showing *revenue growth* (C_1) as the most important criterion and *working capital efficiency* (C_3) as the least important criterion for measuring SCFP in NLNG, while *cost reduction* (C_2) and *fixed asset utilisation* (C_4) remained second and third most preferred measuring criteria respectively. Although the results of the ranking order for the MD division for *revenue growth* (C_1) and *cost reduction* (C_2) are also similar to the NLNG group decision-making in first and second respectively, decision-makers from the MD division ranking of *revenue growth* as a measure of SCFP in NLNG was the highest with an average of 0.4328. However, the MD sub-group ranked working *capital efficiency* (C_3) as the third most important measure for SCFP in NLNG and *fixed asset utilisation* (C_4) as the least important measure. Last, The Shipping division results differed from the NLNG group decision-making, MD, Finance, and Production divisions in its ranking of *cost reduction* (C_2) as the most important criterion and *revenue growth* (C_1) as second most important measurement criterion. However, the Shipping sub-group ranking for *fixed asset utilisation* (C_4) and *working capital efficiency* (C_3) are consistent with the NLNG group, Finance and Production divisions' decision-making as the third and the least important criteria respectively (Table 5.4; Appendices 12-15). Sections of sub-group decisions that have similar priorities with NLNG group rankings are highlighted in grey in subsequent AHP tables and figures for clarity.

Table 5.4: SCFP measurement preference by key NLNG divisions

Divisions	MD		Finance		Production		Shipping	
CR	0.0519		0.0700		0.0003		0.0313	
Priority	Criteria	NW	Criteria	NW	Criteria	NW	Criteria	NW
1st	C_1	0.4328	C_1	0.3136	C_1	0.3252	C_2	0.4215
2nd	C_2	0.2707	C_2	0.3057	C_2	0.2674	C_1	0.4041
3rd	C_3	0.1742	C_4	0.2104	C_4	0.2247	C_4	0.0917
4th	C_4	0.1222	C_3	0.1703	C_3	0.1827	C_3	0.0827
Total weight		1.0000		1.0000		1.0000		1.0000

Source: Author

5.6 Evaluation of alternatives by sub-groups/divisions

Paired comparison of the alternatives with respect to criteria by relevant sub-groups were analysed to obtain relative priorities of SCFP drivers from divisional perspectives. This divisional comparative analysis (Table 5.5: Appendices 12-15) assisted in establishing priorities of each the key relevant divisions at NLNG concerning the SCFP strategies that enhance SCFP (Objectives 4; 5).

Table 5.5: SCFP Ranking of SCFP drivers by key NLNG divisions

Divisions	MD		Finance		Production		Shipping	
CR	0.0519		0.0700		0.0003		0.0313	
Priority	Alt	CW	Alt	CW	Alt	CW	Alt	CW
1st	A_1	0.2969	A_1	0.4197	A_1	0.3159	A_3	0.4738
2nd	A_3	0.2890	A_3	0.2194	A_3	0.2571	A_2	0.2795
3rd	A_4	0.2425	A_2	0.2100	A_4	0.2349	A_4	0.1606
4th	A_2	0.1717	A_4	0.1509	A_2	0.2235	A_1	0.0861
Total weight		1.0000		1.0000		1.0000		1.0000

Source: Author

5.6.1 Ranking of SCFP strategies by the Managing Director division

The collective response from four experts in the MD division regarding SCFP drivers in NLNG were analysed. Results have shown that all the four alternatives were given different priorities by the MD sub-group when compared to ranks given by the whole NLNG group decision-making (Tables 5.5; 5.6; Figure 5.5; Appendix 12).

Table 5.6: Group preference from the Managing Director division

Priority		C_1	C_2	C_3	C_4	Composite weight
	Criteria weight	0.4328	0.2707	0.1742	0.1222	
1st	A_1	0.3226	0.3228	0.2821	0.1692	0.2969
2nd	A_3	0.2716	0.2817	0.2961	0.3564	0.2890
3rd	A_4	0.2192	0.2610	0.2687	0.2462	0.2425
4th	A_2	0.1866	0.1345	0.1531	0.2283	0.1717
Total weight		1.0000	1.0000	1.0000	1.0000	1.0000

Source: Author

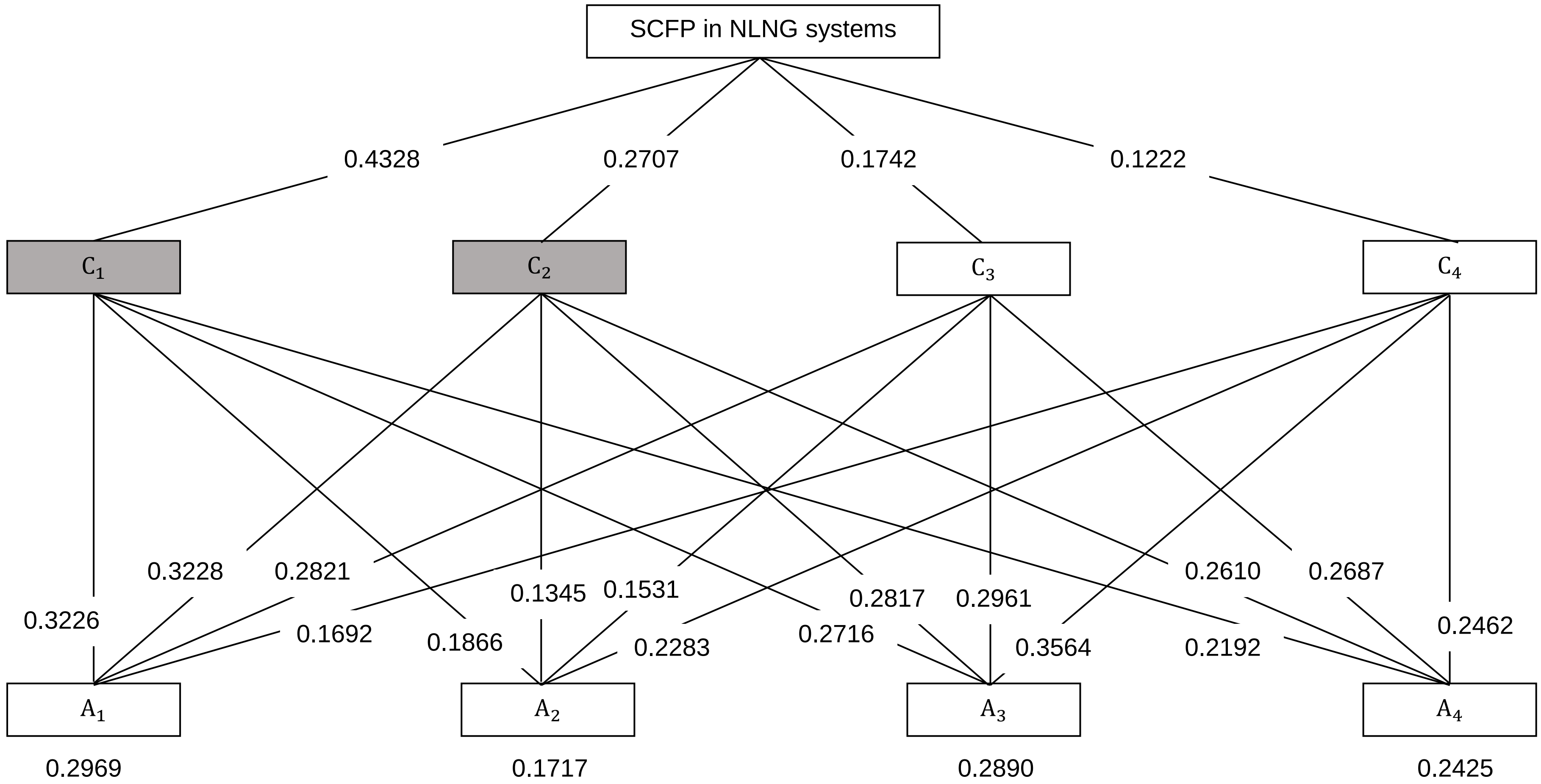
Practitioners in the MD division of NLNG accorded A_1 the highest priority, with a weight of 0.2969. The highest preference given to A_1 resulted from its strong priority against top ranking SCFP measures, C_1 and C_2. This established that *sourcing strategy* has the highest impact on *revenue growth* and *cost reduction* in NLNG supply chain system weighing 0.3226 and 0.3228 respectively. This inferred that *sourcing strategy* has an influence of over 32% on *revenue growth* and *cost reduction* in NLNG system. The decision-makers in the MD division ranked *sourcing strategy* as the number one priority, which conforms to the findings from Finance and Production divisions. However, this is completely contrary to the NLNG group decision-making and the Shipping sub-group where *sourcing strategy* was ranked second and last in terms of priority respectively.

Findings revealed A_3 as the second ranked SCFP driver by group of respondents from the MD division, with a composite weight of 0.2890, which is just 0.79% lower than *sourcing strategy* in the overall ranking. The high preference given to A_3 was because of strong priority vectors of *integration and collaboration* against all the measurement criteria with 0.2716, 0.2817, 0.2961, and 0.3564 influence on *revenue growth*, *cost reduction, working capital efficiency*, and *fixed asset utilisation*. *Integration and collaboration* is also ranked second by the Finance and the Production sub-groups respectively. This support the number one rank accorded to *integration and collaboration* by the larger NLNG group.

A_4 was ranked third by experts in the MD division, with a composite weight of 0.2425. Although A_4 was ranked third in the MD sub-group, it was much higher than A_2 (0.1717), this was largely due to its strong priority vectors of 0.2610 and 0.2687 in relation to *cost reduction* and *working capital efficiency*. This implied that *sustainability strategy* has an influence over 26% on both *cost reduction* and *working capital efficiency* in NLNG system from the perspective of the MD sub-group. These findings from the MD division ranked *sustainability* strategy as the third priority, which conforms to the findings from Production and Shipping divisions. *Sustainability* was the third ranking driver of SCFP in NLNG by all the sub-groups, except the Finance division which gave *sustainability* fourth, which explains the results from the NLNG group decision-making where *sustainability* has the least ranking amongst all the other SCFP drivers in NLNG.

The MD division established A_2 as the least prioritised SCFP driver, with a composite weight of 0.1717. The lowest preference accorded to A_2 was because it has the least priority vector in relation to C_2 and C_3 as SCFP measures with 0.1345 and 0.1531 respectively. This implied that *IT and automation* strategies have the lowest impact on *cost reduction* and *working capital* respectively. Ranking for *IT and automation* by the MD division was consistent with the rank given by the Production division as the least driver of SCFP in NLNG systems. However, these findings are contrary to those for of NLNG group decision-making which ranked *IT and automation* as third. This was shown to be greatly influenced by responses from Shipping and Finance divisions in which *IT and automation* was ranked second and third in each of the sub-divisions.

Figure 5.5: The Managing Directors sub-group decision model for SCFP in NLNG systems



Source: Author

5.6.2 Ranking of SCFP strategies by the Finance division

Sub-group decision-making by four experts from the Finance division regarding SCFP drivers in NLNG systems were analysed. Findings indicated that the ranking of two alternatives, *IT and automation* and *sustainability* conformed to the NLNG group decision-making as third and fourth respectively. However, the ranks for *sourcing strategy* and *integration and collaboration* differed from the larger NLNG group (Tables 5.5; 5.7; Figure 5.6; Appendix 13).

Table 5.7: Group preference from the Finance division

Priority		C_1	C_2	C_3	C_4	Composite weight
	Criteria weight	0.3136	0.3057	0.1703	0.2104	
1st	A_1	0.4420	0.4553	0.3703	0.3747	0.4197
2nd	A_3	0.1953	0.2736	0.2232	0.1734	0.2194
3rd	A_2	0.2019	0.1608	0.2465	0.2639	0.2100
4th	A_4	0.1608	0.1102	0.1600	0.1880	0.1509
Total weight		1.0000	1.0000	1.0000	1.0000	1.0000

Source: Author

Similar to the findings of MD and Production divisions, findings from the Finance sub-group decision-making established A_1 as the number one driver of SCFP in NLNG systems, with a composite weight of 0.4197, which is higher than the weights given to *sourcing strategy* by any counterpart division. The highest preference given to A_1 was a result of its strong priority vector against top ranking SCFP measures, C_1 and C_2. This represented that *sourcing strategy* has the highest impact on *revenue growth* and *cost reduction* in NLNG system with 0.4420 and 0.4553 priority vectors respectively. Results implied that *sourcing strategy* has an influence of over 44% on *revenue growth* and over 45% on *cost reduction* in NLNG systems. The ranking of *sourcing strategy* as number one driver of SCFP in NLNG by the Finance division conforms to the findings from

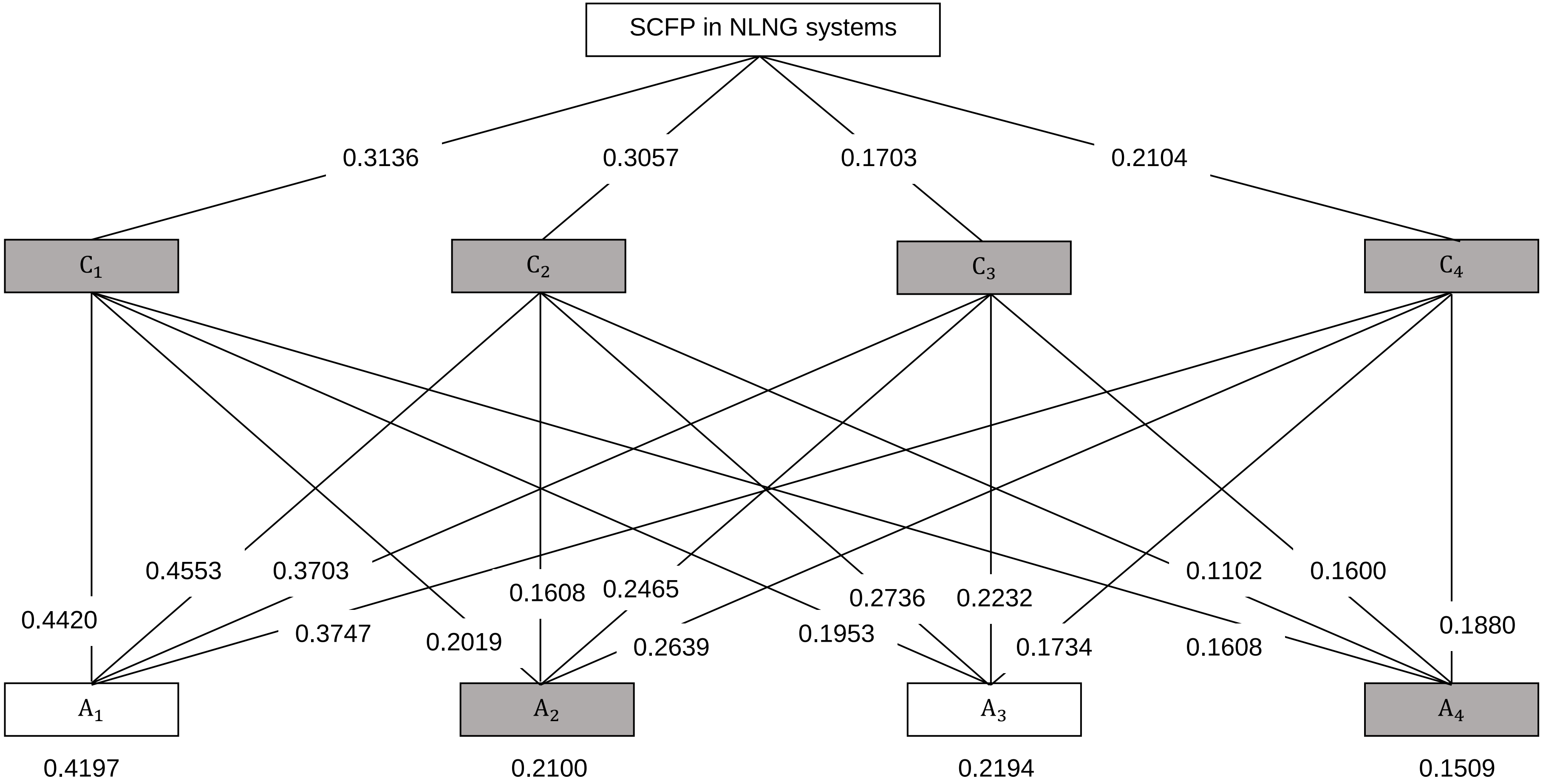
MD and Production divisions respectively. However, this differed from NLNG group decision-making and the Shipping sub-group where *sourcing strategy* was ranked second and last in terms of priority respectively.

Results revealed A_3 as the second ranked SCFP driver by the group of respondents from the Finance division, with a composite weight of 0.2194. Although *integration and collaboration* ranked second, it was over 20% lower than *sourcing strategy* as a priority for driving SCFP in NLNG. The second position given to A_3 reflected *integration and collaboration*'s strong priority vectors of 0.2736 and 0.2232 with respect to *cost reduction* and *working capital efficiency* respectively. *Integration and collaboration* was also ranked second by the MD and the Production sub-groups respectively. Results further highlighted the reason why *integration and collaboration* was regarded as number one SCFP driver by the larger NLNG group.

Empirical analysis of sub-group decision-making from the Finance division revealed A_2 as the third prioritised SCFP driver, with a composite weight of 0.2100. A_2 was slightly lower than A_3 because of its low priority vector in relation to C_2 as SCFP measure 0.1608. This implied that *IT and automation* strategies have the second lowest impact on *cost reduction*. However, the ranking of *IT and automation* by the Finance division conformed to that of the NLNG group decision-making group, which equally ranked *IT and automation* as third. *IT and automation* was ranked second by the Shipping division and fourth by MD and Production divisions.

A_4 was the least ranked driver of SCFP in NLNG by experts from the Finance division, with a composite weight of 0.1509. This minimal ranking was largely due to weak priority vectors of *sustainability* strategy to all the SCFP measurement criteria in NLNG. Findings from the Finance division revealed that *sustainability* strategy has only 0.1608, 0.1102, 0.1600 and 0.1880 priority vectors to *revenue growth, cost reduction, working capital efficiency* and *fixed asset utilisation* respectively. The ranking of *sustainability* strategy from the Finance division conformed to that of the NLNG group, which also ranked *sustainability* strategy as the least ranking strategy that drives SCFP in NLNG systems. Further analysis revealed that *sustainability* was ranked third by the other three sub-groups, which explains the results from the NLNG group decision-making where *sustainability* has the least ranking amongst all the other SCFP drivers in NLNG networks.

Figure 5.6: The Finance sub-group decision model for SCFP in NLNG systems



Source: Author

5.6.3 Ranking of SCFP strategies by the Production division

Response regarding SCFP drivers in NLNG by four decision makers from the Production division were analysed. Findings revealed the same ranking to that of the MD division, which indicated that *sourcing strategy*, *integration and collaboration, sustainability*, and *IT and automation* are the first, second, third and fourth priorities that drive SCFP in NLNG systems respectively. In addition, the ranking for *sourcing strategy* as number one by the Production division conformed to that of the Finance division and number three ranking for *sustainability* strategy conformed to results from the Shipping division. However, none of the ranks agrees with that of the larger NLNG group (Tables 5.5; 5.8; Figure 5.7; Appendix 14).

Table 5.8: Group preference from the Production division

Priority		C_1	C_2	C_3	C_4	Composite weight
	Criteria weight	0.3252	0.2674	0.1827	0.2247	
1	A_1	0.2152	0.2562	0.3927	0.4705	0.3159
2	A_3	0.2938	0.2663	0.1834	0.2530	0.2571
3	A_4	0.3155	0.2570	0.2042	0.1169	0.2349
4	A_2	0.1755	0.2205	0.2197	0.2997	0.2235
Total weight		1.0000	1.0000	1.0000	1.0000	1.0000

Source: Author

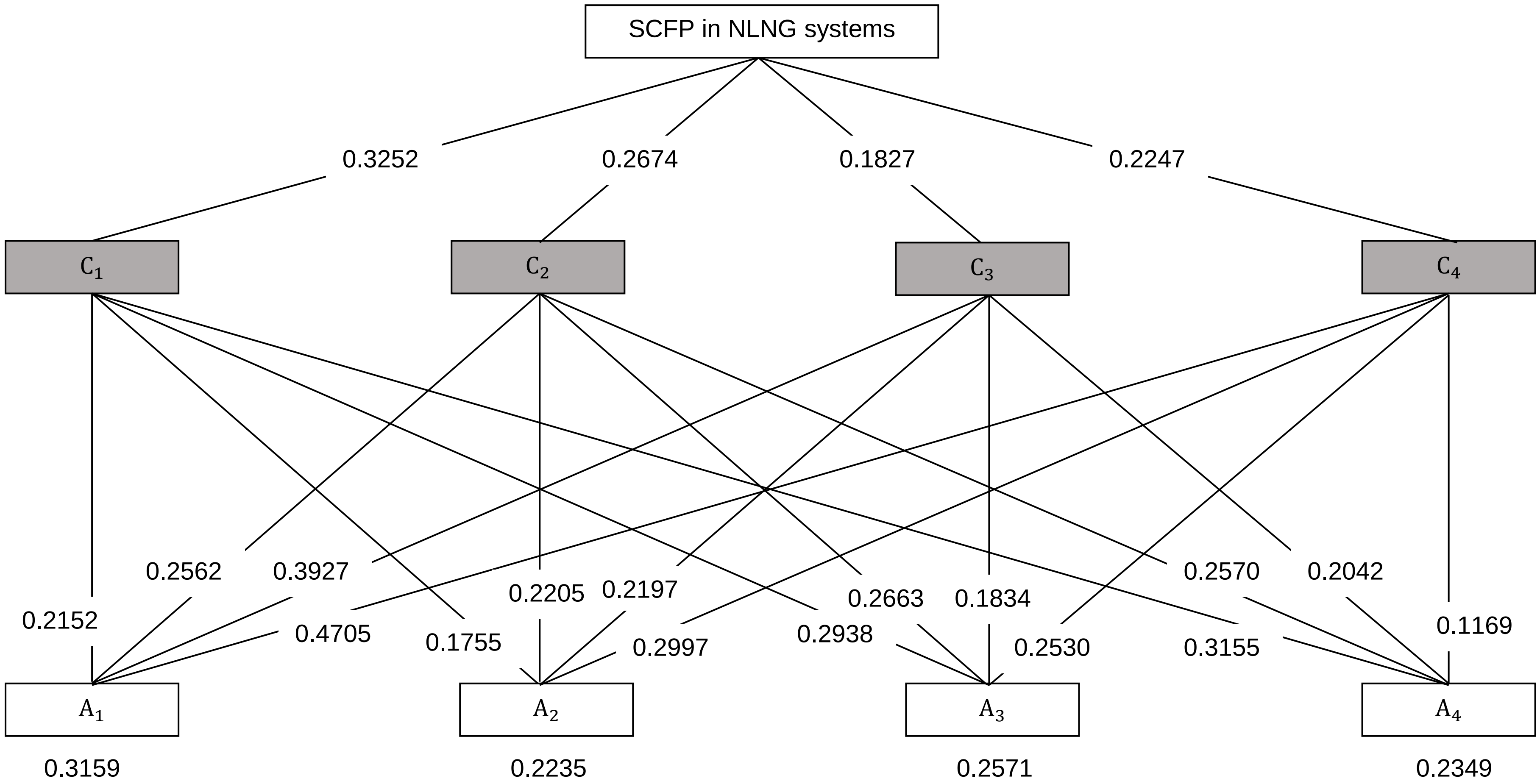
Results from the Production sub-group decision-making established A_1 as the number one driver of SCFP in NLNG systems, with a composite weight of 0.3159, which is the second highest weight given to *sourcing strategy* by any counterpart division beside the Finance division with 0.4197. However, unlike the Finance sub-group decision-making, the highest preference given to A_1 by the Production sub-group was an outcome of its strong priority vector against the SCFP measures C_3 and C_4. This represented that *sourcing strategy* has the highest impact on *working capital efficiency* and *fixed asset utilisation* in NLNG systems with 0.3927 and 0.4705 priority vectors respectively. Findings indicated that *sourcing strategy* has an influence of over 39% on *working capital efficiency* and over 45% on *fixed asset utilisation* in the NLNG networks. The ranking of *sourcing strategy* as number driver of SCFP in NLNG by the Production division corroborated the results from MD and Finance divisions respectively. However, it shows disparity to the ranking by the larger NLNG group decision-makers and the Shipping sub-group where *sourcing strategy* was ranked second and last in terms of priority respectively.

Similar to decision-making by MD and Finance division, results revealed A_3 as the second ranked SCFP driver by the group of respondents from the Production division, with a composite weight of 0.2194. The second position given to A_3 arose because of *integration and collaboration*'s strong priority vectors of 0.2938 and 0.2663 with respect to the top ranking SCFP measures, C_1 and C_2. This represented that *integration and collaboration* has an impact of over 29% on *revenue growth* and an influence of over 27% on *cost reduction* in NLNG systems respectively. Production division, along with MD and Finance divisions all ranked *integration and collaboration* as the second priority that drives SCFP in NLNG systems. This further explained the reason why *integration and collaboration* was ranked number one by the larger NLNG decision-making group.

A_4 was the third ranked driver of SCFP in NLNG by professionals from the Production division, with a composite weight of 0.1323. This minimal ranking was largely due to weak priority vectors of *sustainability* strategy in relation to all the SCFP measurement criteria in NLNG systems. Findings from the Finance division revealed that *sustainability* strategy has only 0.1608, 0.1102, 0.1600 and 0.1195 priority vectors to *revenue growth, cost reduction, working capital efficiency* and *fixed asset utilisation* respectively. The ranking of *sustainability* strategy from the Production division conformed to that of the MD and Shipping divisions, which also ranked *sustainability* strategy as the third ranking supply chain strategy that drives SCFP in NLNG. This further explains the results from the NLNG group decision-making where *sustainability* has the least ranking amongst all the other SCFP drivers in NLNG networks.

Production sub-group decision-making group prioritised A_2 as the least SCFP driver, with a composite weight of 0.2235. The low preference accorded to A_2 was due to its very low priority vector of 0.1755 in relation to C_1 as a SCFP measure. Findings indicated that *IT and automation* strategy has an impact of only 17.55% on *revenue growth* according to decision-makers in the Production division. However, the ranking of *IT and automation* by the Production division is consistent with that of the MD sub-group which both ranked *IT and automation* as last. *IT and automation* was ranked second and third by Shipping and Finance divisions respectively.

Figure 5.7: The Production sub-group decision model for SCFP in NLNG systems



Source: Author

5.6.4 Ranking of SCFP strategies by the Shipping division

Findings from analysis of the Shipping division's decision-making sub group indicated that *integration and collaboration* was given the highest preference, which conformed to the group decision-making by the NLNG group. However, the ranks for *sourcing strategy*, IT and collaboration, and *sustainability* differed from the larger NLNG group. Further findings revealed that all decision-making from the Shipping sub-group regarding the ranking of drivers for financial performance do not match those from the other sub-groups, except for *sustainability* strategy where it was equally ranked third by MD and Production sub-groups (Tables 5.5; 5.5; Figure 5.8; Appendix 15).

Table 5.9: Group preference from the Shipping division

Priority		C_1	C_2	C_3	C_4	Composite weight
	Criteria weight	0.4041	0.4216	0.0827	0.0917	
1st	A_3	0.5193	0.5323	0.3941	0.0760	0.4738
2	A_2	0.2228	0.3328	0.3185	0.2489	0.2795
3	A_4	0.1744	0.0717	0.1783	0.4924	0.1606
4	A_1	0.0835	0.0632	0.1090	0.1827	0.0861
Total weight		1.0000	1.0000	1.0000	1.0000	1.0000

Source: Author

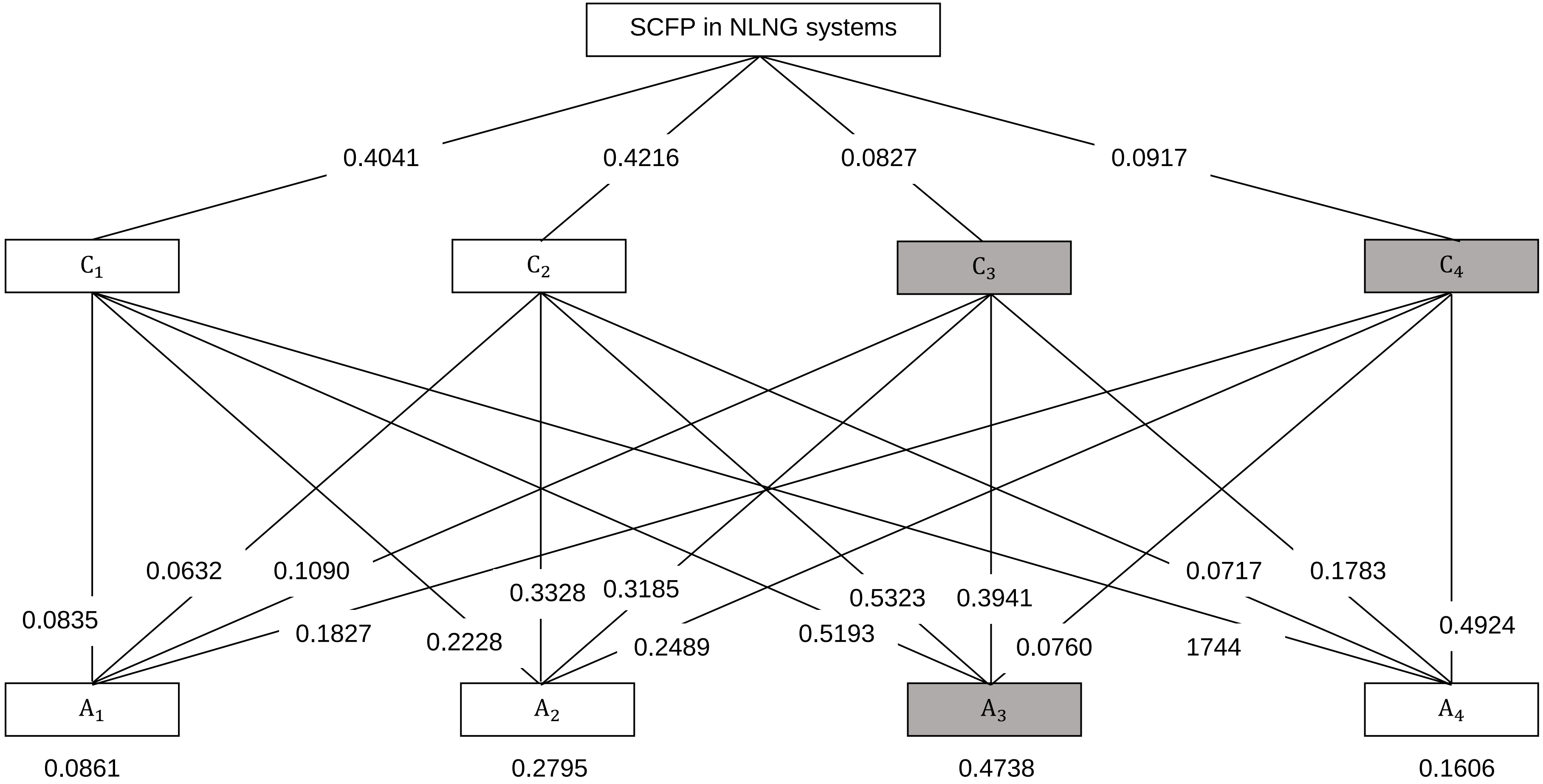
Analysis of Shipping sub-group decision-making revealed A_3 as the number one driver of SCFP in NLNG systems, with a composite weight of 0.4738. The highest preference given to A_3 by the Shipping sub-group was as a result of its strong priority vector against SCFP measures C_1, C_2.and C_3, represented *integration and collaboration* as having the highest impact on *revenue growth, cost reduction* and *working capital efficiency* in the NLNG network with 0.5193, 0.5323 and 0.3941 priority vectors respectively. This inferred that *integration and collaboration* has influence of over 51%, 53% and 39% on *revenue growth, cost reduction* and *working capital efficiency* in the NLNG system. The ranking of *integration and collaboration* as number one driver of SCFP is the highest weight given to any alternative in this study. The number one priority given to *integration and collaboration* by the Shipping sub-group conformed to the findings from the NLNG group decision-making which also ranked *integration and collaboration* as the number one strategy that drives SCFP in NLNG networks. Although other counterpart divisions rated *integration and collaboration* in second position, it does affect its overall ranking because it was rated highly by all divisions.

Decision made by the Shipping sub-group established A_2 as the second prioritised SCFP driver in NLNG systems, with a composite weight of 0.2795. The high preference accorded to A_2 was because it has strong priority vectors in relation to C_2 and C_3 as SCFP measures 0.3328 and 0.3185 respectively. This implied that *IT and automation* strategy has an impact of 33.28% on *cost reduction* and an influence of 31.85% on *working capital efficiency* according to decision-makers in the Shipping division. This second position is the highest rank given to *IT and automation* strategy; all other divisions ranked this strategy between third or fourth. This further explains the third place ranking of *IT and automation* by the NLNG group decision-making.

A_4 as driver of SCFP in NLNG was ranked third by experts in the shipping division, with a composite weight of 0.1606. Although A_4 was ranked third in the Shipping sub-group, it was much higher than A_1 which had only 0.0861, which was largely due to its strong priority vector of 0.4924 in relation to fixed *assets utilisation* as a measure for SCFP in NLNG networks. Findings indicated that *sustainability* strategy has an influence of over 49% on *fixed asset utilisation* in NLNG systems from the perspective of the Shipping sub-group. Results from the Shipping division ranked *sustainability* strategy as the third priority, which conformed to the findings from MD and Production divisions. *Sustainability* was the third ranking driver of SCFP in NLNG by all the sub-groups, except the Finance division that accorded *sustainability* fourth, which explained the results from the NLNG group decision-making where *sustainability* has the least ranking amongst all the other alternatives that drives SCFP in NLNG systems.

Amongst the SCFP drivers, A_1 was accorded the least priority by practitioners in the Shipping division of NLNG, with a composite weight of 0.2969. The lowest preference given to A_1 was because of its low priority vector against top ranking SCFP measures, C_1 and C_2. Findings revealed that *sourcing strategy* has a low impact on *revenue growth* and *cost reduction* in the NLNG system with 0.1744 and 0.0717 priority vectors respectively. Results indicated that *sourcing strategy* has influence of only 17.44% and 7.17% on *revenue growth* and *cost reduction* respectively in the NLNG system. The decision-makers in the Shipping division ranked *sourcing strategy* as the least important driver of SCFP in NLNG networks. This differed fundamentally from all the other sub-divisions that ranked *sourcing strategy* as the most important driver of SCFP in NLNG. Findings further deviate from the NLNG group ranking of *sourcing strategy* as the second most important driver of SCFP in NLNG systems.

Figure 5.8: The Shipping sub-group decision model for SCFP in NLNG systems



Source: Author

5.7 Factors that drive SCFP strategies in NLNG systems

To achieve objectives four and six of this study, so far this chapter has analysed SCFP capabilities established in study phase one in the NLNG case study. In accordance with the AHP group decision-making technique, these capabilities are ranked in order of preference based on NLNG expert's group decision-making. To enhance the quality of this study, this section presented and analysed data relevant to the factors that influence SCFP capabilities that were collected from 22 practitioners at NLNG using a Likert-scale survey (Appendix 6).

Results from data analysis established the degree of impact of each of the factors identified from study phase one to the SCFP capabilities at NLNG networks. Findings facilitated the critical assessment of SCFP capabilities in NLNG systems and assisted in proposing appropriate strategies and policies to improve SCFP in NLNG networks (Objectives 4; 6).

5.7.1 Factors that influence sourcing strategy in NLNG systems

Participants at NLNG prioritised *sourcing strategy* as the second most important driver of SCFP in NLNG networks (Table 5.3; Figure 5.4). To optimise the impact of *sourcing strategy* in NLNG supply chains, opinions of experts at NLNG were analysed to measure the influence of key factors established in study phase one on *sourcing strategy* as a SCFP driver in NLNG systems (Appendix 6).

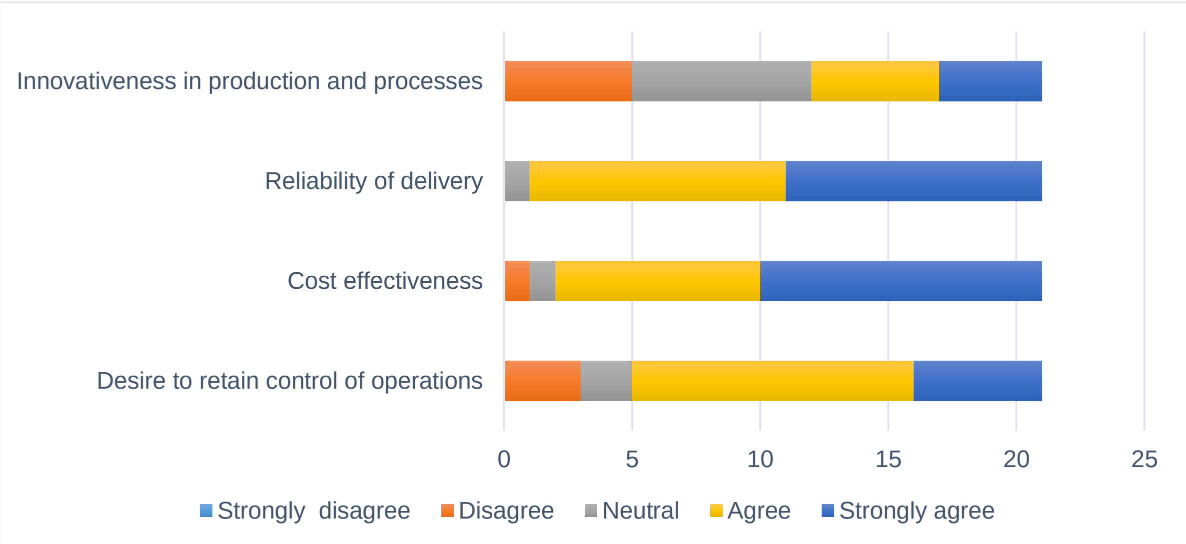
Certain sourcing strategies within supply chains such as make-or-buy decisions, outsourcing and sub-contracting have raised concerns regarding *retention of control* by supply chain participants. A majority (52%) of respondents from NLNG "agreed" with the assertion that the *desire to retain control of operations* is a key consideration for designing and implementing of *sustainability* strategy in NLNG systems to optimise financial results. Additionally, 24% of participants “strongly agreed”, which emphasised the significance that should be given to *retention of control.* Only 10% of respondents remained “neutral” and 14% “disagreed” with this proposition (Figures 5.9; 5.10). Findings revealed that the *desire to retain control of operations* should be considered in decision-making pertaining *sourcing strategy* as an important driver of SCFP in NLNG systems.

According to TCE, the key element behind *sourcing strategy* in supply chains is to *minimise purchasing and production associated costs across supply chains*. *Cost effectiveness* is a key factor in make-or-buy decisions, outsourcing and sub-contracting in supply chain systems. Results supported the influence of *cost effectiveness* on sources decision in NLNG networks, where a majority of 52% of respondents “strongly agreed” that *cost control* drives *sourcing strategy* in NLNG systems. In addition, 38% of participants “agreed” with this statement. This implied that 90% of targeted professionals have either “strongly agreed” or “agreed” with the influence of *cost management* on *sourcing strategy* in NLNG supply chains.

Reliable delivery, flexibility and responsiveness are key concerns when making strategic sourcing decisions by supply chain participants. Empirical findings support this proposition. A vast number of respondents from NLNG, 48%, “strongly agreed” that *reliability of delivery* influences *sourcing strategy* in NLNG supply chains, and 48% of participants further “agreed” with this statement. None of the participants “disagreed” and only one respondent remained “neutral” with the influence of *reliability of delivery* on NLNG’s *sourcing strategy* which accentuated the importance that should be given to the reliability of delivery.

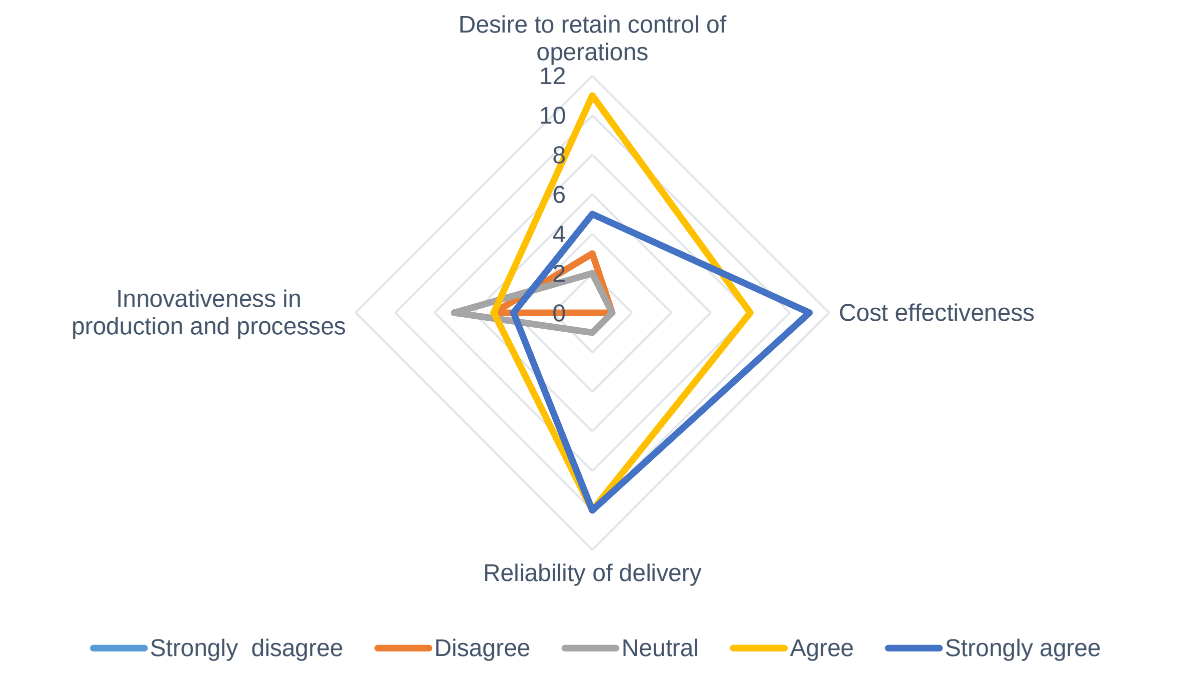
Study phase one established that the *desire for innovativeness across supply chain operations and processes* has an influence on *sourcing strategy*. However, empirical findings revealed mixed results, showing a weak relationship between *innovativeness in production and processes* and *sourcing strategy*, especially when compared to other established factors. Many (33%) respondents from NLNG remained "neutral" to this proposition, and an additional 24% of participants "disagreed" that *innovativeness in production and processes* has an impact on NLNG supply chains' *sourcing strategy*. Only 24% of respondents "agreed" and 19% "strongly agreed" with the effect of *innovativeness in production and processes* to *sourcing strategy*.

Figure 5.9: Stacked bar of factors that affect sourcing strategy



Source: Author

Figure 5.10: Radar indicating factors that affect sourcing strategy



Source: Author

Analysis indicated that all the factors recognised have an influence on *sourcing strategy* in NLNG networks. However, *reliability of delivery* and *cost effectiveness* established a very strong influence where respectively, 95% and 90% of the professionals indicated that they either “strongly agreed” or “agreed” with the impact of these factors on *sourcing strategy* as the second most important driver of SCFP in NLNG. However, the effect of *innovativeness in production and processes i*s minimal. To improve SCFP, much emphasis should be given to *cost effectiveness* and *reliability of delivery* when making sourcing decision in NLNG distribution systems.

5.7.2 Factors that influence IT and automation in NLNG systems

Decision-makers at NLNG categorised *IT and automation* as the third ranking driver of SCFP in NLNG (Table 5.3; Figure 5.4). To improve the impact of *IT and automation* in NLNG systems, views of experts at NLNG were analysed to access the influence of key factors established in study phase one on *IT and automation* as a driver of SCFP in NLNG (Appendix 6).

IT and automation expedites *information flow,* within and across supply chains. Access to state of the art automated machines such as modern LNG trains and vessels, as well as IT infrastructure, facilitates *information sharing* which in turn enhances SCFP. This study supported the influence of *information flow* when making strategic decisions relevant to *IT and automation* in NLNG systems. Results revealed that 55% of participants “agreed” that *IT and automation* facilitates *information flow* and the remaining 45% respondents “strongly agreed”. In total 100% of targeted experts have either “strongly agreed” or “agreed” with the impact of *information flow* on strategic decisions regarding *IT and automation*. Findings emphasised the significance that should be given to information flow when making *IT and automation* related decisions to improve SCFP in NLNG systems.

Delivery of goods and services across the supply chains and most especially to customers are supported by *IT and automation* supply chain tools including e-collaboration and e-business applications and tools such as electronic ERP, RFID, electronic data interchange (EDI) and electronic ordering system. This meant that the performance of *delivery systems* needs to be carefully considered when making *IT and automation* strategies in supply chains. Empirical results supported the influence of *delivery performance* in *technology implementation* in NLNG systems, where a majority of 68% of respondents from NLNG “agreed” that *delivery performance* influence *IT and automation* decision-making. In addition, 23% of participants “strongly agreed” with this statement (Figures 5.11;

5.12). Results demonstrated that delivery performance has a major influence on *IT and automation* as a driver of SCFP in NLNG supply chains.

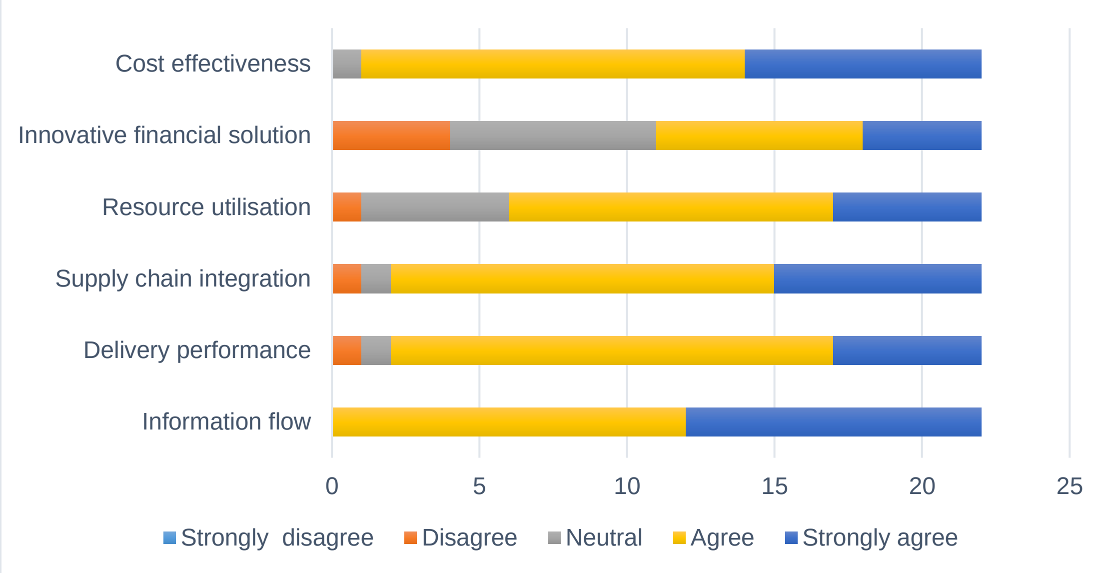
Study phase one has found that *supply chain integration and collaboration* is a driver of SCFP. Findings further established that *supply chain integration and collaboration* is an enabler supply chain *IT and automation* as a driver of SCFP. Results supported these propositions where a majority of 59% of respondents from NLNG “agreed” and 32% of participants “strongly agreed” that *supply chain integration and collaboration* drives *IT and automation* decisions in NLNG systems (Figures 5.11; 5.12). Findings established that *supply chain integration and collaboration* should be considered in decision-making pertaining to *IT and automation* strategy as an important driver of SCFP in NLNG networks.

According to RBV, resource utilisation is pivotal in optimising SCFP. *Resource utilisation* is a key factor to be considered when making strategic decisions regarding *IT and automation* by supply chain participants. Results supported this proposition, where the largest grouping of 50% of respondents from NLNG “agreed” with this assertion, and additionally 23% “strongly agreed” that *resource utilisation* impacts *IT and automation* strategy in NLNG network. However, another 23% of the participants remained “neutral” regarding the influence of *resource utilisation* on NLNG *IT and automation* (Figures 5.11; 5.12). *Resource utilisation* should be emphasised in decision-making concerning *IT and automation* as an important driver of SCFP in NLNG systems.

Study phase one established that *innovative financial solutions* such as an electronic ordering system have an influence on *IT strategy*. However, empirical findings revealed mixed results, showing a weak relationship between *innovative financial solution* and *IT and automation* strategy, especially when compared to other established factors. Although, 32% of respondents agreed with the influence of *innovative financial solution* on *IT and automation* strategy, only 18% of participants “strongly agreed” with this assertion. Another 32% of respondents remained “neutral” and 18% “disagreed” (Figures 5.11; 5.12). This indicated that only 50% of targeted experts have either “strongly agreed” or “agreed” with the effect of *innovative financial solutions* on *IT and automation* strategy at NLNG systems. This established that *innovative financial solutions* are not a major factor that influence *IT and automation* strategy as a driver of SCFP in NLNG supply chains.

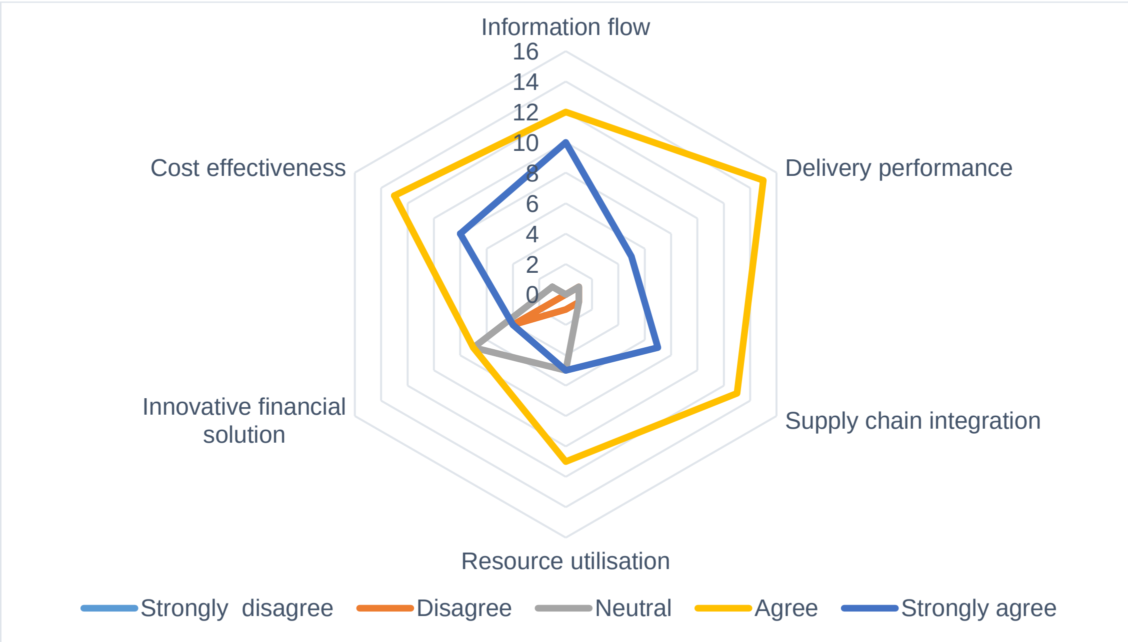
In line with TCE, one of the key components behind investment in *IT infrastructure and automation* resource in supply chains is to *minimise purchasing and production associated logistics costs* across supply chain systems. Results also revealed that *cost effectiveness* drives *IT and automation strategy*, where a majority of 59% of respondents from NLNG “agreed”. In addition, 36% of participants “strongly agreed” with this statement and only one respondent remained “neutral”. This implied that 95% of the professionals that were approached have either “strongly agreed” or “agreed” with the influence of *cost* management on *IT and automation* strategy in NLNG supply chains (Figures 5.11; 5.12). Results supported that *cost* minimisation has a major influence on decisions relevant to *IT and automation* as a driver of SCFP in NLNG networks.

Figure 5.11: Stacked bar of factors that affect IT and automation



Source: Author

Figure 5.12: Radar indicating factors that affect IT and automation



Source: Author

Results indicated that all the identified factors have an influence on *IT and automation* supply chain capability in NLNG systems. However, *information flow; cost effectiveness; delivery performance;* and *supply chain integration and collaboration* presented a very strong influence respectively, with 100%, 95%, 91% and 91% of the targeted experts approached indicating either "strongly agreed” or “agreed” with the influence of these factors on *IT and automation* as a driver of SCFP in NLNG networks. However, the influence of *innovative financial solution* is minimal. To enhance SCFP, special attention should be given to the four factors identified above when making *IT and automation* investment decisions in NLNG supply chains.

5.7.3 Factors that influence integration and collaboration in NLNG supply chains

Integration and collaboration was given the highest priority in group decision-making by relevant professionals at NLNG (Table 5.3; Figure 5.4). In an attempt to optimise the impact of *integration and collaboration* strategy in NLNG systems, opinions of experts at NLNG were analysed to measure the influence of key factors established in study phase one on *integration and collaboration* as a SCFP driver in NLNG systems (Appendix 6).

Study phase one established *internal integration* within supply chain systems as a sub-set of *integration* and enabler of *external integration* as well as supply chain *integration and collaboration*. In line with organisational learning theory, strategic choice theory, KBV and RVB, *internal integration* supports cross-functional integration and management functions within and across supply chains. *Internal integration* also facilitates internal information flow integration. Results revealed that *internal integration* is the most important factor to be considered in formulating *integration and collaboration* strategy. A majority of 67% of respondents from NLNG “strongly agreed” with the influence *internal integration* on *integration and collaboration* strategy. In addition, 28% of participants “agreed” with this statement, which implies that 95% of targeted professionals have either “strongly agreed” or “agreed” with the impact of *internal integration* on *integration* *and collaboration* strategy in NLNG systems. Only one respondent “disagreed” with this assertion (Figures 5.13; 5.14). Results validated that *internal integration* has a major influence on *integration and collaboration* as the prime driver of SCFP in NLNG supply chains.

Similar to internal integration, study phase one also found that *external integration* facilitates *integration and collaboration*. *External integration* consists of upstream integration with suppliers and downstream integration with customers. *Integration and collaboration* with suppliers and customers facilitates supply chain information flow integration, supply chain reliability, long-term relationship with partners, trust, cooperation and commitment, customer service, and reduction in the frequency and intensity of supply chain glitches. Findings supported the impact of *external integration* on supply chain *integration and collaboration*, as 48% of respondents from NLNG “agreed” with this assertion, and additionally 28% of participants “strongly agreed”, which accentuated the significance that should be given to external integration. However 24% of the participants remained “neutral” regarding the influence of external integration on NLNG *integration and collaboration* strategy. Overall 76% of the professionals approached by this study have either “strongly “agreed”” or “agreed” that external integration impacts *integration and collaboration* strategies (Figures 5.13; 5.14).

Integration and collaboration enable *information sharing* within and across supply chains which in turn enhances SCFP. This study corroborated the influence of *information flow* when making strategic decisions relevant to *integration and collaboration* in NLNG networks. Results established the influence of *information flow* on *Integration and collaboration*, as a large proportion of respondents from NLNG (48%) “strongly agreed” with this assertion, and additionally 48% of participants also “agreed” with this statement which supported the importance that should be given to information flow in formulating *integration and collaboration* strategy in NLNG networks. Only one respondent (5%) remained “neutral” so that in total 95% of targeted experts have either “strongly agreed” or “agreed” that *information flow* impacts *integration and collaboration* strategy (Figures 5.13; 5.14). Results showed that *information flow* should be carefully considered in decision-making pertaining to *integration and collaboration* strategy as an important driver of SCFP in NLNG networks.

Integration and collaboration enhances information flow across the supply chain, which in turn reduces the *risk of financial exposure* between supply chain participants. Empirical findings supported this proposition, where a majority of 67% of respondents from NLNG “agreed” with the impact of *financial risk exposure* on *integration and collaboration.* Additionally 14% of participants “strongly agreed” and the remaining 19% of the participants remained “neutral” regarding the influence of *financial risk exposure* to NLNG *integration and collaboration* strategy (Figures 5.13; 5.14). Findings have shown that financial risk exposure should be emphasised in decision-making concerning *integration and collaboration* as the main driver of SCFP in NLNG supply chains.

Trust, cooperation and commitment is necessary to establish or implement required mechanisms for supply chain *integration and collaboration* such as integrated IT infrastructure and information sharing. Results established the influence of *trust, cooperation and commitment* on *integrative and collaborative* supply chains, where a majority of 52% of respondents from NLNG “strongly agreed” with this proposition and additional 43% of participants “agreed” with this statement. Findings shown only one respondent who remained “neutral”, which implied that 95% of targeted professionals have either “strongly agreed” or “agreed” with the impact of *trust, cooperation and commitment* on supply chain *integration and collaboration* strategy in NLNG supply chains (Figures 5.13; 5.14). Results demonstrated *that trust, cooperation and commitment* has a major influence on *integration and collaboration* strategy as a driver of SCFP in NLNG systems.

According to RBV*, integration and utilisation of IT infrastructure* as a key resource is essential in optimising SCFP. In line with RBV, *integrated IT infrastructure* facilitates supply chain alignment, supply chain analytic, e-collaborations, B2B *supply chain integration*, upstream and downstream *integration*, material flow information, document sharing, collaborative forecasting, collaborative planning and automated payments. *Integrated IT infrastructure* is an important factor to be considered when making strategic decisions regarding supply chain *integration and collaboration* by supply chain participants. Findings supported the impacts of *IT infrastructure* on chain *integration and collaboration*, where 43% of respondents “agreed” and additionally 33% of participants “strongly agreed” with this statement, which emphasised the significance that should be given to *integrated IT infrastructure*. However, 19% of the participants remained “neutral” regarding the influence of *integrated IT infrastructure* on NLNG supply chain *integration and collaboration* strategy, and one respondent “disagreed” with this proposition. Overall 76% of the professionals approached by this study have either “strongly agreed” or “agreed” that *integrated IT infrastructure* drives supply chain *integration and collaboration* strategies (Figures 5.13; 5.14).

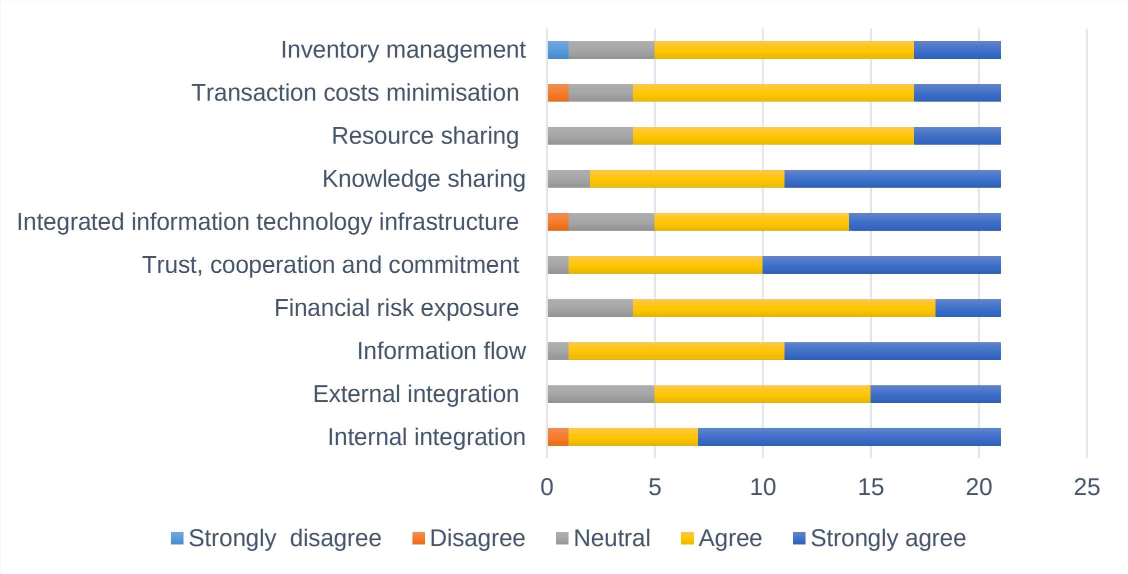
According to KBV, *integration and collaboration* facilitates *knowledge sharing* within and across supply chains, which enhances SCFP. This study corroborated the influence of knowledge sharing when making strategic decisions relevant to *integration and collaboration* in NLNG systems. Results indicated that a major proportion of respondents, 48%, "strongly agreed" and additionally 43% of participants also "agreed" with the influence of *knowledge sharing* in formulating *integration and collaboration* strategy in NLNG. In total 91% of targeted experts have either "strongly agreed" or "agreed" that *knowledge sharing* drives *integration and collaboration* strategy (Figures 5.13; 5.14). Findings established that *knowledge sharing* should be carefully considered in decision-making pertaining to *integration and collaboration* strategy as a key driver of SCFP in NLNG supply chains.

In line with RBV, *resource sharing* in supply chain systems is an important asset that improves SCFP. Resource sharing should be considered when making strategic decisions regarding *integration and collaboration* by supply chain participants. Empirical findings supported this proposition, where a majority of 62% of respondents from NLNG "agreed" and 19% of participants "strongly agreed" with the impact of *resource sharing* on *integration and collaboration* (Figures 5.13; 5.14). Findings have shown that *resource sharing* should be taken into consideration when making decisions regarding *integration and collaboration* as the most important driver of SCFP in NLNG systems.

According to TCE, the major factor behind supply chain *integration and collaboration* strategy in supply chains is to *minimise production and associated logistics costs* across supply chains. Results corroborated this proposition, where a majority of 62% of respondents from NLNG "agreed" and additionally 19% of participants "strongly agreed" with the influence of *transaction cost minimisation* on *integration and collaboration.* Although, 14% of respondents remained "neutral" and 5% "disagreed" with this proposition, in total 81% of targeted experts have either "strongly agreed" or "agreed" that *transaction costs minimisation* drives *integration and collaboration* strategy (Figures 5.13; 5.14). Findings revealed that the *costs minimisation* should be emphasised in decision-making pertaining *integration and collaboration* strategy as an important driver of SCFP in NLNG networks.

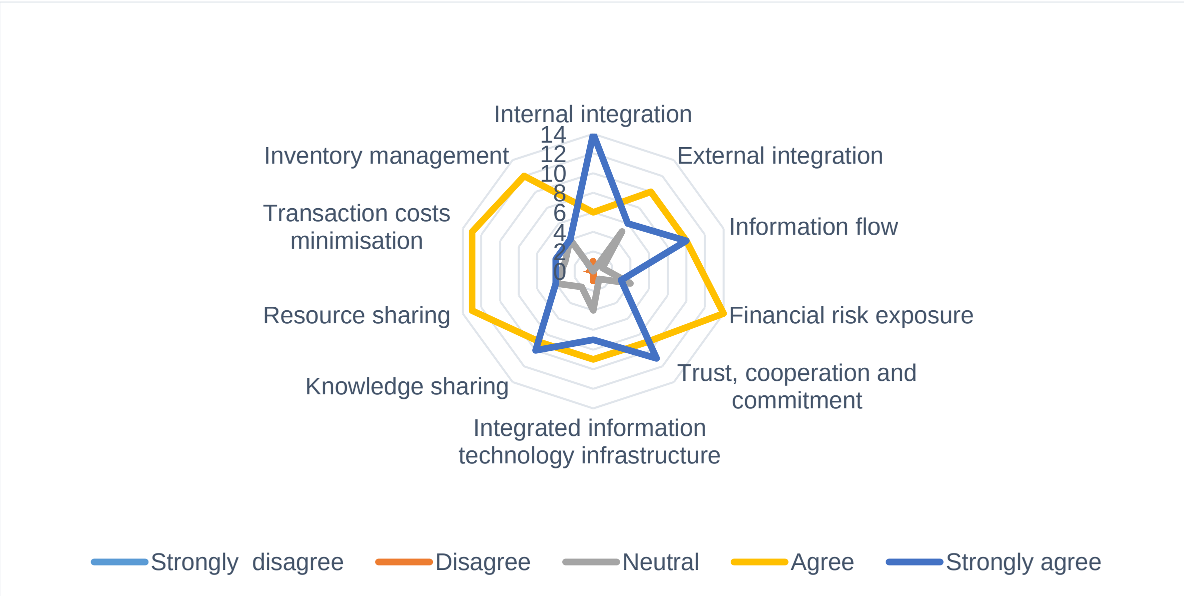
From study phase one, inventory is a major *cost* factor in production and logistics processes. Inventory exists in every value chain across supply chain systems. Supply chain *integration and collaboration* is targeted towards improving *efficiency in inventory* across supply chains, which should in turn lead to *cost minimisation* and eventually enhance SCFP. Empirical findings supported the impacts of *inventory management* on *integration and collaboration*, where a majority of 57% of respondents from NLNG "agreed" with this assertion, and 19% of participants "strongly agreed" with this statement. However, 19% of respondents remained "neutral" and one participant "disagreed" with the influence of *inventory management* on NLNG supply chain *integration and collaboration* strategy (Figures 5.13; 5.14). Results have shown that *inventory management* should be emphasised in decision-making concerning *integration and collaboration* as the most important driver of SCFP in NLNG supply chains.

Figure 5.13: Stacked bar of factors that affect integration and collaboration



Source: Author

Figure 5.14: Radar indicating factors that affect integration and collaboration



Source: Author

Findings indicated that all the factors identified have a strong influence on *integration and collaboration* in NLNG. However, *internal integration; information flow; trust, cooperation and commitment; and knowledge sharing* established a very strong influence (95%, 95%, 95% and 91% respectively) on *integration and collaboration* as the key driver of SCFP in NLNG systems. To improve SCFP in

NLNG, much emphasis should be given to all the established factors, especially the four mentioned above, when making and implementing *integration and collaboration* strategic decisions in NLNG networks.

5.7.4 Factors that influence sustainability in NLNG supply chains

Decision-makers at NLNG recorded *sustainability* in supply chains as the lowest ranking driver of SCFP in NLNG systems (Table 5.3; Figure 5.4). Although professionals ranked *sustainability* the lowest, it still has a significant influence on SCFP in NLNG networks with a composite weight of 0.2127. To improve the impact of *sustainability* strategy in NLNG supply chains, views of experts at NLNG were analysed to measure the influence of key factors established in study phase one on *sustainability* as a driver of SCFP in NLNG (Appendix 6).

Global competitiveness and increasing awareness about business environment and stakeholders, have encouraged supply chains to become more *ethical and to engage more in CSR related activities*. Findings indicated that 45% of respondents from NLNG “agreed” that the *drive for corporate responsibility and ethical consideration* influences *sustainability* decisions in supply chains, and additionally 41% of participants “strongly agreed” with this statement, which emphasised the significance that should be given to CSR and ethical considerations. However, 9% of the participants remained “neutral” regarding the influence of CSR and ethical consideration on NLNG *sustainability* strategy, and only one respondent “disagreed” with the impacts of *corporate responsibility and ethical consideration*. Overall 86% of the professionals approached by this study have either “strongly agreed” or “agreed”, it is established that *CSR and ethical considerations* should be fully considered in decision-making concerning *sustainability* as a driver of SCFP in NLNG systems.

Certain *sustainability* strategies such as fair remuneration and HSSE schemes have raised concerns regarding *employee wellbeing and satisfaction* within supply chains. Results corroborated the impacts of *employee satisfaction* on NLNG *sustainability* strategy, where a majority of 54% of respondents “agreed” and an additional 23% of participants “strongly agreed” with this statement. Only 9% of respondents remained “neutral” and 13% “disagreed” with this proposition. In total 76% of targeted experts have either “strongly agreed” or “agreed” that the impact that *employee satisfaction* has is a significant component of *sustainability* strategy in NLNG systems (Figures 5.15; 5.16). Findings indicate that employee satisfaction should be emphasised in decision-making pertaining to *sustainability* strategy as a driver of SCFP in NLNG supply chains.

Health and safety is part of employee satisfaction discussed above; however, its scope extends beyond the boundaries of supply chains, considering the potential effect that supply chains activities can have on the life and properties of third parties. Findings revealed that *health and safety agenda* is the most important factor to be considered in formulating *sustainability* strategy in NLNG systems. Overwhelmingly, a majority of 68% of respondents from NLNG “strongly agreed” and an additional 23% of participants “agreed” with the impacts of *health and safety agenda* on NLNG *sustainability* strategy. This implied that 91% of targeted professionals have either “strongly agreed” or “agreed” that health and safety agenda drives *sustainability* strategy in NLNG supply chains (Figures 5.15; 5.16). Results validated that *health and safety* has a significant influence on *sustainability* strategy as a driver of SCFP in NLNG networks.

Environmental concerns are key agenda items in today’s business strategy due to the danger posed by the impacts of business operations which may generate *pollution and other carbon footprints*. Empirical results supported the influence of *pollution, carbon footprint and other environmental considerations* in formulating *sustainability* strategy in NLNG systems, where a majority of 50% of respondents from NLNG "agreed" and 36% of participants "strongly agreed (Figures 5.15; 5.16). Findings corroborated that *environmental considerations* should be fully considered in decision-making relating to *sustainability* strategy as a driver of SCFP in NLNG systems.

According to the principles of triple-bottom line, sustainable supply chains' performance encompassing social and environmental performance, will ultimately lead to *economic or financial performance*. This suggests that economic *considerations* is a driver of sustainable supply chain strategy. Findings were overwhelming, in that 73% of participants "agreed" and 23% "strongly agreed" and only one respondent "disagreed" that *economic consideration* is not a driver for *sustainable* strategy in NLNG networks. In total 96% of targeted experts have either "strongly agreed" or "agreed" with the impact of *economic benefits* on NLNG'S *sustainability* strategy (Figures 5.15; 5.16). These findings emphasised the significance that should be given to *economic factors* when making *sustainability* related decisions to improve SCFP in NLNG supply chains.

Sustainable practice in supply chains forms part of *financial risk management* strategy since it contributes toward to avoiding damage or loss of assets, and mitigates against claims and fines that may arise as a result of non-compliance. Empirical results corroborate this proposition, where a majority of 59% of respondents from NLNG "agreed" and 18% of participants "strongly agreed" with this statement, which emphasised the significance that should be given to *financial risk management*. Although, the remaining 23% of the participants remained “neutral”, overall 77% of the professionals approached by this study have either “strongly agreed” or “agreed” that *financial risk management* drives *sustainability* strategies in NLNG systems (Figures 5.15; 5.16). Findings have shown that *financial risk management* should be taken into consideration when making decisions regarding *sustainability* as a driver of SCFP in NLNG networks.

Many industries enjoy *reduction in charges and taxes* by adhering to certain *sustainability* guidelines, which serves as an incentive to incorporate *sustainable* strategy as part of their supply chain strategy. Findings do not show a strong relationship between *tax benefits* and *sustainability* strategy in NLNG, especially when compared to other established factors. Although, 41% respondents “agreed” and 23% “strongly agreed”, 27% of the respondents remained “neutral”, and one respondent “strongly disagreed” that tax advantages have influence on NLNG *sustainability* strategy. Overall only 64% of the targeted experts have either “strongly agreed” or “agreed” with the impacts of *tax benefits* on *sustainability* strategies (Figures 5.15; 5.16). Findings established that the influence of *tax advantages* are not a major determinant of *sustainability* strategy as a driver of SCFP in NLNG systems.

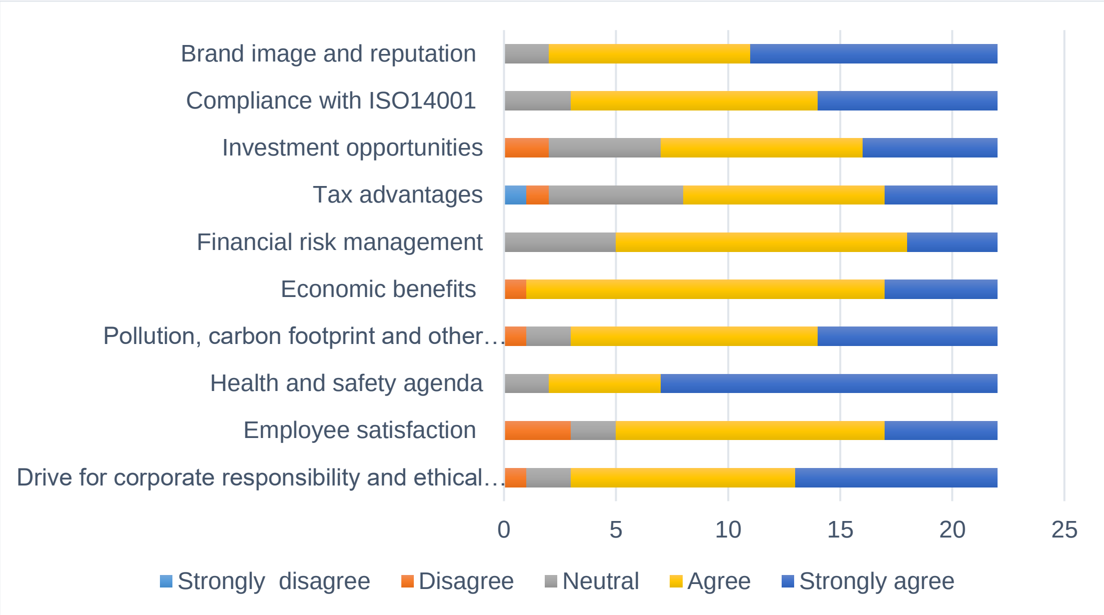
Study phase one established that sustainable supply chains are more *appealing to investors*, including both equity and debt financiers. Such *investment opportunities* serve as incentives to incorporate *sustainability* into supply chain strategy. Findings corroborated this proposition, as 41% of respondents from NLNG “agreed” and an additional 27% of participants “strongly agreed” with the impacts of *investment opportunities* on suitability *strategies*. However, 23% of respondents remained “neutral” and two respondents “disagreed” that investment opportunities drive *sustainability* strategy in NLNG system (Figures 5.15; 5.16).

Results established that *investment opportunities* should be considered in decision-making pertaining to *sustainability* as a driver of SCFP in NLNG supply chains.

Compliance with ISO14001 is key to NLNG *sustainability*. *ISO14001* provides guidelines for environmental practices which if adequately incorporated into NLNG supply chain strategy will minimise associated environmental risks and improve SCFP. Empirical results upheld this assertion, as 50% of respondents from NLNG “agreed” and an additional 36% of participants “strongly agreed” with this assertion. Findings revealed that 86% of the respondents have either “strongly agreed” or “agreed” that *ISO14001* drives *sustainability* strategy in NLNG supply chains. However, 14% of respondents remained “neutral” (Figures 5.15; 5.16). Findings corroborated that *compliance with ISO14001* has a major influence on decisions relevant to *sustainability* as a driver of SCFP in NLNG networks.

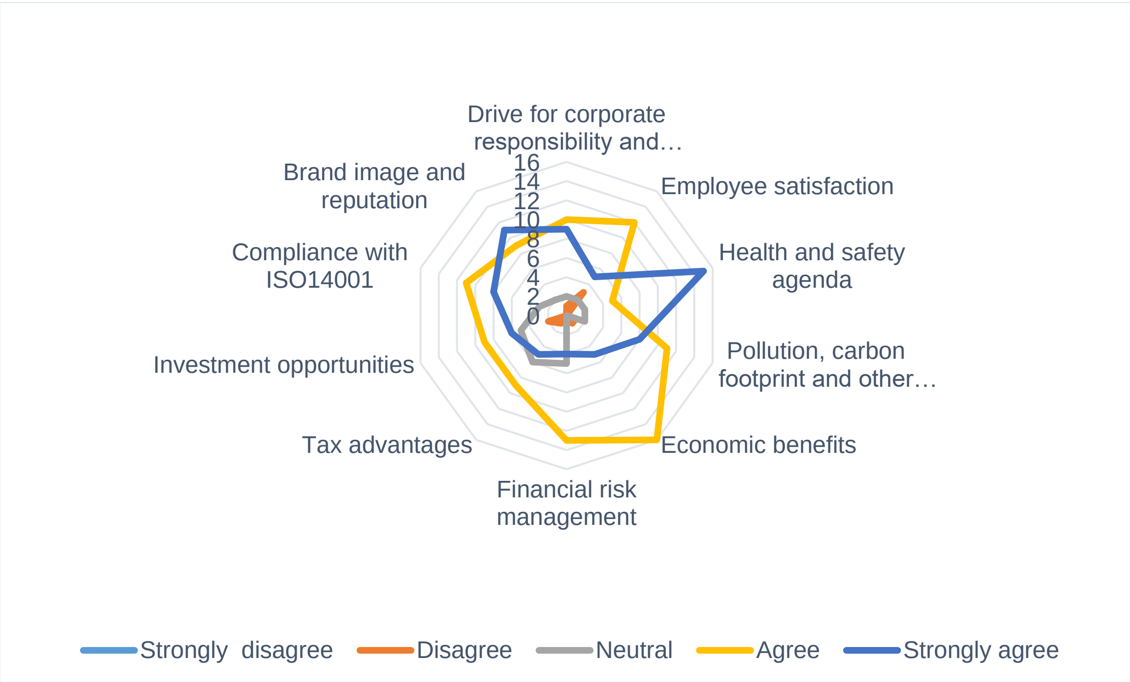
Brand image and reputation is a major competitive tool in todays’ global business environment. *Sustainability* practices enhance *supply chain image and reputation* to their various stakeholder groups. Findings established the influence *of brand image and reputation* to *sustainable supply chains*, whereby 50% of respondents from NLNG “strongly agreed” and an additional 41% of participants “agreed”. Results shown that 91% of respondents have either “strongly agreed” or “agreed” that *brand image and reputation* impacts *sustainability* strategy in NLNG systems. Only two respondents remained “neutral” regarding the influence of *brand image and reputation* on *sustainability* (Figures 5.15; 5.16). Findings demonstrated that *brand image and reputation* has a major influence on *sustainability* strategy as a driver of SCFP in NLNG systems.

Figure 5. 15: Stacked bar of factors that affect sustainability



Source: Author

Figure 5. 16: Radar indicating factors that affect sustainability



Source: Author

Analysis indicated that all the factors identified affect *sustainability* strategy in NLNG systems. However, *economic benefits; health and safety agenda; and brand image* and *reputation* presented a very strong influence, respectively with

90% each agreeing with the impact of these factors on *sustainability* as a driver of SCFP. However, the impact of *tax advantages* and *investment opportunities* is not very strong. To improve SCFP, much attention should be given to all the drivers, especially the three identified above, when making *sustainability* decisions in NLNG supply chains.

5.8 Discussion of key quantitative study findings

To achieve objectives four and six of this study, this section critically discussed study phase two empirical findings in relation to relevant SCF and LNG literature, as well as archived industry data reviewed in study phase one. The SCFP drivers and measures established in study phase one were analysed based on their priorities as established using AHP method in study phase two. In addition, to address the research question effectively, findings from the analysis of the factors that drive SCFP capabilities in NLNG are also discussed simultaneously.

5.8.1 The effect of supply chain integration and collaboration on NLNG SCFP

The supply, production and delivery of LNG requires substantial capital investments and operating expenses. The growing market competition has made it necessary for international corporations to *integrate* their functions within and across supply chains, as well as to *collaborate* with relevant third parties, including competitors to maximise *revenues* and *reduce costs*. Optimum supply chain *integration and collaboration* strategy is imperative for NLNG to improve its SCFP and to survive in this highly volatile industry. Amongst the four SCFP drivers established in study phase one, *integration and collaboration* was accorded the highest priority by practitioners at NLNG, meaning that it is the major driver of SCFP in NLNG systems. This is largely due to the significant influence that supply chain *integration and collaboration* has on *revenue growth* and *cost reduction* as key drivers of financial performance in NLNG systems.

Internal supply chain integration and collaboration influence SCFP in NLNG by supporting the movements of information and material between the extensive midstream value chains which involves gas supply, gas treatment, liquefaction, LNG storage, terminal operations, and LNG transportation using ocean going vessels. *External supply chain integration and collaboration* enhances NLNG SCFP by facilitating the movements of information and material between NLNG and upstream suppliers and downstream customers. Empirical findings corroborated that trust has a major influence on *supply chain integration and collaboration* in NLNG networks. This is not surprising considering that the most global LNG trade requires LTCs to secure intensive capital investments in the LNG supply chains and safeguard income stability for the LNG suppliers like NLNG. However, due to price volatility across oil and gas markets and excess LNG production, the LNG spot market is growing very rapidly. To survive in such a dynamic and complex market, NLNG should carefully plan production, inventory, and delivery in a *cost-effective* way by utilising its *integration and collation capabilities.* Optimum *NLNG supply chain integration and collaboration* strategy encompasses supply chain planning problems at strategic, tactical, and operational decision levels. Strategic planning involves *supply chain integration and collaboration* relevant to production capacity and vessel investments as well as LTCs. Tactical planning involves developing *supply chain integration and collaboration* strategy to facilitate feed gas supply, inventory, and delivery planning to fulfil the LTCs. Operational planning involves formulating *supply chain integration and collaboration* strategy to manage both planned and unplanned developments including vessel breakdowns, port unavailability, variations in travel times, and emerging spot sales opportunities (Mutlu *et al.,* 2016).

Proposition five: *Supply chain "integration and collaboration" strategy as the number one driver of SCFP in NLNG systems has to be carefully evaluated and planned due to its significant influence on information and material flow as well as knowledge and resource utilisation. Supply chain "integration and collaboration" in NLNG also has influence on sourcing strategy, sustainability, and especially IT and automation. To maximise supply chain "integration and collaboration" strategy and enhance SCFP in NLNG networks, strategy should incorporate mutual trust, cooperation and commitment plans, as well as deployment of relevant integrative IT infrastructure. The LNG market is changing rapidly, due to a growing spot market, changing contractual terms and various degrees of supply and demand mismatch. In this regard, NLNG networks may consider a "collaborative delivery" strategy which will allow for split deliveries of cargoes as proposed by Mutlu, et al. (2016), which could lead to substantial reductions in shipping costs and increase in volume delivery that could boost production and revenue. "Collaborative transportation" management can significantly reduce costs and improve the flexibility in supply chains, especially under a demand disruption environment (Lia and Chan, 2012). "Collaboration" minimises travel time and enhances speed of delivery, which in turn improves sustainable supply chains to reduce economic, environmental and social costs (Zissis et al., 2018). In addition, NLNG should continue to "collaborate" with its long-term customers to explore alternative commercial initiatives such as the diverting of LNG cargos to high value markets. Supply chain "integration and collaboration" strategy should also incorporate explicit plans for market expansion.*

5.8.2 The effect of sourcing strategy on NLNG SCFP

Sourcing strategy involves make-or-buy decisions such as outsourcing, sub-contracting, offshoring, and leasing. Different *sourcing strategies* can be utilised based on need, cash flow, net present value (NPV) and expertise towards acquiring, leasing hiring and procurement of fixed assets, labour, consumables and feedgas as raw material for NLNG systems. Both directly and indirectly, *sourcing* takes 100% of NLNG supply chain *capital and operating costs*, and as such, consideration has to be given to decisions pertaining to *sourcing strategy*. Study phase one has established *sourcing strategy* as a driver of SCFP, nevertheless, much emphasis was given to *integration and collaboration*, and *IT and automation* as superior drivers of SCFP. However, in study phase two, AHP analysis ranked *sourcing strategy* as the second most important driver of SCFP in NLNG systems with a very strong impact on *revenue growth, cost reduction,* and *working capital efficiency*. To further emphasise the impact of *sourcing strategy* on SCFP in NLNG systems, sub-group decision-makers from MD, Finance and Production divisions all ranked *sourcing strategy* as the number one SCFP driver in NLNG networks, with only the Shipping sub-group ranking *sourcing strategy* as fourth. This is not surprising considering how availability and supply of feedgas influence *investment*, operations and the profitability of NLNG supply chains.

Empirical results upheld that *cost effectiveness* and reliability of delivery has a major influence on *sourcing strategy* in NLNG networks. This is not surprising considering that akin to other oil and gas production plants, LNG projects are located close to a *feedgas source* either offshore or onshore to *minimise cost* and maximise capacity. That is why all major LNG liquefaction plants are located in gas producing countries like Nigeria, which signifies the degree of influence that *source of raw material* has on LNG production. Findings further demonstrate that sourcing-strategy is amongst the first set of decisions undertaken by LNG investors to determine the location of their *investment* which is informed by the availability of gas amongst other things. NLNG plant is located in Bonny Island in the oil and gas reach region of Niger Delta is a good example, however, all subsequent efforts by the Nigerian government to establish additional LNG projects such as the proposed Brass LNG and OKLNG have failed so far. In addition, there are *feedgas supply threats* in the form of pipeline vandalism to the existing NLNG project due to security challenges in Niger Delta region, which has contributed to the declining LNG export volume from NLNG (Clarksons, 2017). The former NLNG Chief Executive Officer (CEO) lamented that "*the security of our gas supply systems remained a critical challenge, with threats to gas supply reliability; including four major GTS's leaks due to third party sabotages*" (NLNG, 2016: 19). These views further explained why NLNG group decision-makers gave priority to *sourcing strategy* as a driver of SCFP in NLNG systems. Although *sourcing strategy* is key to any LNG supply chain, there is a possibility that it is even more important to NLNG due to challenges peculiar to the NLNG supply network.

Proposition six: *"Sourcing strategy" as the second most important driver of SCFP in NLNG systems has to be meticulously assessed and planned, because it is established that threat to "feedgas source" can lead to shutdown of the entire NLNG network. To improve "sourcing strategy" and enhance SCFP in NLNG systems, strategy should incorporate necessary surveillance and security measures to mitigate against third party sabotage. Another option that should be explored by NLNG is the possibility of investing in an offshore liquefaction platform, which will not only bring added security that will mitigate against pipeline* *vandalism but will also boost liquefaction capacity and financial performance. The Nigerian government should provide an enabling environment for LNG investors by improving the existing pioneer tax breaks, improve local infrastructure and address socio-political unrest. This will assist in establishing other projects in other parts of the Niger Delta such as the Brass LNG project where despite initial investment of USD 547M, the shareholders are reluctant to sign the FID (Thisday, 2017).*

5.8.3 The effect of IT and automation on NLNG SCFP

Automation in NLNG supply chains includes gas processing machineries, LNG trains, storage tanks, harbour equipment and LNG vessels. The *IT infrastructure* is the network structure that facilitates information sharing and *integration* by interconnecting various machines, facilities, departments and value chains within and across the NLNG supply chains. Although experts at NLNG ranked *IT and automation* as the third most important driver of SCFP in NLNG system, *IT and automation* has significant influence on all the other three drivers, especially on *integration and collaboration*. In addition, the majority of NLNG capital outlay is invested in *IT and automation infrastructure*. This explains why *IT and automation* has the highest impact on *assets utilisation* as a measure of financial performance in NLNG networks. The capital *cost* of a liquefaction train can be as high as USD600 p.a., while capital *cost* of an LNG vessel ranges between USD 200M and USD 400M, and the *costs* of daily vessel charters average around USD 60k (Mutlu *et al.,* 2016; Tusiani and Shearer, 2007). In light of these figures, much consideration has to be given by decision-makers at NLNG to *IT and automation* strategy to minimise associated *costs*, improve utilisation and ensure income stability for NLNG supply chain participants.

LNG export is a highly automated project with state of the art technologies embedded across the entire value streams. LNG liquefaction capacity is increasing both on and offshore. Shell is constructing its gigantic prelude with a capacity of 3.6 Mtpa off the coast of Western Australia to compete with Inpex's Ichthys that has 8.9 Mtpa, for access to gas in the Browse Basin. Prelude is the largest sea-faring vessel ever constructed, at 488m or 1,600ft long. Prelude is the first floating facility that has been designed to not only collect gas from sub-sea wellheads, but also to liquefy and store LNG on-board, something that has never been achieved on such a scale before. It is envisaged that Australia may overtake Qatar to become the world's top exporter of LNG once Ichthys and Prelude are in full operation. Another project is under consideration by Eni, a floating facility off the coast of Mozambique; it will have a slightly smaller capacity than Prelude at 3.4 Mtpa. One other comparable vessel is the Allseas' Amazing Grace, an enormous twin-hulled construction ship due to be built over the coming years. Amazing Grace's function will be to lift offshore platforms, however, just like Ichthys, it does not convert gas into LNG (BBC, 2018). The LNG ocean-going vessels are also becoming more sophisticated due to advance in technologies. The modern vessels have: the capability to burn boil-off gas; shut-down in emergency situations; carry much safer tanks with multiple layers and automated monitoring devices; advanced navigational radar and communication systems; and vessel tracking tool. *Technology* has also evolved so that it is now possible to transport and regasify LNG on-board special LNG vessels without requiring a *costly* onshore terminal. Companies such as Excelerate Energy and Höegh LNG are developing their supply chains based on this technology (Sönmez *et al.* 2013).

The NLNG network has advanced and *integrated IT* systems and is active in modernising its vessel fleet. It has established BGTPlus project, which involves the construction of six 170,000 M^3 duel fuel diesel electric (DFDE) vessels in which three were delivered in 2015 and the balance delivered in 2016 and have since commenced operations. The BGTPlus project has also promoted the training of over 600 Nigerians in ship building skills (NLNG, 2016). The major challenge facing NLNG *IT and automation* strategy is the NLNG train 7 project which is still in the FEED stage and has seen its start-up date moved back further to 2020 from an original start-up date of 2012 (Clarksons, 2017).

Proposition seven*: "IT and automation" strategy is vital to any LNG producer like NLNG, a single strategic investment like the Prelude can increase the global competitiveness of NLNG which will result in gestalt financial benefits to its supply chains. Strategy should be developed to ensure that NLNG train 7 projects come to fruition. "IT and automation" strategy should consider the possibility of setting up offshore liquefaction projects. This will not only improve capacity but will also bring added security that will mitigate against third party sabotage such as the pipeline vandalism that caused force majeure in 2015. However, because "IT and automation" decision-making is dealing with the most capital intensive aspects of NLNG supply chains, decisions should be made based on the technology configuration that maximises the NPV generated by NLNG supply chains for each technology option, and at any given LNG throughput requirement.*

5.8.4 The effect of sustainability on NLNG SCFP

Increasing energy demand and scarce petroleum resources necessitates that communities adapt to a rapidly changing ecosystem, and that socio-economic environments are transformed by oil and gas developments. *Sustainability* has been established by extant SCM and LNG literature as a driver of SCFP. In study phase two, AHP analysis upheld the impact of *sustainability* on financial performance measured by *revenue growth, cost reduction, working capital efficiency,* and *fixed asset utilisation.* Amongst the four SCFP drivers established in study phase one, *sustainability* was ranked third by MD, Production, Shipping sub-groups respectively, and was ranked last by the Finance sub-group. Consequently, compared to other SCFP drivers, *sustainability* was found to have the least effect on SCFP in NLNG systems.

NLNG has embraced *sustainability* and a *sustainability* agenda is at the core of its strategy. Similar to the missions of all the major LNG exporting countries reviewed by this study, NLNG's mission is:

> *"to market, produce and deliver LNG and Natural Gas Liquids (NGLs) to buyers safely, reliably and profitably, growing our company and its people to their full potential, and being a trusted partner with all our stakeholders in the sustainable development of Nigeria's gas industry and of our host communities".*

The presiding CEO reported that NLNG has conducted and managed its operations to ensure that the release of substances do not harm the environment. He also stated that the company has completed 98.5% of the environmental, social and health assessment and management plan. The former CEO further conveyed that NLNG has successfully carried out re-certification of standards and surveillance audit for ISO-14001 on its assets (NLNG, 2016:18). However, *sustainability* concerns in NLNG operations goes beyond LNG production, it includes sustainable development of maritime operations consisting of environmental and social concerns in relation to terminal operations, ship movements, and bunkering of NLNG vessels. An accessible framework supports planning of more sustainable maritime operations, facilitates mitigation of potential risks and encourages supply chain participants to engage with *sustainability* agendas and manage development proposals proactively (Kuznetsov, *et al*., 2017; Dinwoodie, *et al.,* 2012).

NLNG remains committed to making a positive contribution to the sustainable development of Nigeria and host communities through strategic engagement with key stakeholders. NLNG has sustained support in local infrastructural development such as roads and education with its University Support Projects in six Nigerian universities, in addition to the local undergraduate and overseas post-graduate scholarships awarded by NLNG. Additionally, in 2015, NLNG signed a Memorandum of Understanding (MoU) for a sustainable socio-economic development of Bonny Kingdom which was underpinned by the Bonny Master Plan and pledged a substantial annual monetary contribution towards its realisation.

Notwithstanding, environmental organisations and local inhabitants of Bonny Island and neighbouring Niger-Delta communities strive for more environmental and community development in relation to NLNG operations by engaging in negotiations with NLNG and the Nigerian government, which the indigenous people considered to be overshadowed by economic goals, implemented by a strong relationship between NLNG and the Nigerian government. These developments are similar to the findings of van Bets *et al.,* (2016) regarding the environmental and social concerns of Hammerfest people in Norway on LNG production by Statoil, which opened up the Barents Sea for oil and gas drilling. Sustainable development of LNG production is inhibited by centralised decision-making by the institutional partners. NLNG's agenda for environmental and community development could be perceived as being underpinned by the notion of *cost-efficient* and short-term goals. A key challenge with *sustainability* strategy for oil and gas companies is to balance the often-conflicting pressures created by economic performance versus environmental degradation and social disruption (Matos and Hall, 2007).

NLNG's investment in sustainable development have the potential to yield more benefits, because it will bode well with host community, international NGOs, regulators and other stakeholders. However, CSR adaptation as a sustainable shipping practice is influenced by institutional pressure; however, companies are more sensitive to customer expectations (Tang and Geraka, 2018). Interestingly, LNG producers like the NLNG will be the beneficiaries of the IMO sustainable development drive on marine fuel emission restrictions, whereby vessels can only discharge 0.1% of sulphur compared with 1.5% in Sulphur Emission Control Areas (SECA) pre- 2015, and a planned global revision from 3.5% to 0.5% by 2020. To achieve this, all existing vessels must either use scrubbers to burn residual fuels; use low sulphur gasoil; or use LNG (Fesharaki, 2017; Semolinos, 2013). As such, the global sustainable development agenda could result in additional markets for LNG suppliers by having more ship owners and shipping lines as potential customers.

Proposition eight: "*Sustainability" in NLNG supply chains does not only drive financial performance, but also has the ability to influence sourcing strategy, IT and automation, integration and collaboration to drive SCFP in NLNG systems. NLNG should maintain its CSR agenda, which is "driven by a strategic vision of being a trusted partner in the sustainable development of Nigeria and its host communities" (NLNG, 2016:14). An optimal "sustainability" strategy by NLNG presupposes that environmental action and social development should be given* *equal importance as economic gain. NLNG should develop a holistic framework to promote and enhance "sustainability" awareness and nurture commitment to incorporate "sustainability" with supply chain strategy. Corporate decision-making should ensure that the sustainable development agenda is integrated and maintained throughout NLNG supply chains. SCR related activities by oil and gas networks attract political support and enhance public perception (Ite, 2007). Strategic "sustainability" decisions should be carried out in consultation with the host communities, while taking into consideration relevant local and international regulatory frameworks. This will serve as a bridge to reduce tension between eagerness for community development by host communities and centralised decision-making by NLNG.*

5.9 Unexpected findings from quantitative analysis

Findings from study phase two revealed a notable surprise with respect to the ranking of *sustainability* as a driver for SCFP in NLNG systems. Empirical results from AHP analysis of responses from relevant decision-makers ranked *sustainability* as the lowest dominant driver of SCFP supply chains. *Sustainability* is the least priority SCFP driver in NLNG systems due to its poor ranking in terms of its influence on *revenue growth, cost reduction* and *working capital utilisation* as financial performance measures. This was not expected at the beginning of this study, because scoping studies had established that NLNG has embraced *sustainability* and a *sustainability* agenda is at the core of its strategy. Similar to the missions of all the major LNG exporting supply chains, *sustainability* is central to the NLNG mission statement. Results revealed that despite NLNG compliance and conscious participation in *sustainable development* programs, there are scepticisms regarding the positive impact of *sustainability* on NLNG financial results.

However, there are some variations concerning the ranking of *sustainability* as a driver of SCFP in NLNG systems from key divisions in NLNG. Sustainability was ranked last by the Finance division, and was ranked third by MD, Production, Shipping divisions respectively. Consequently, compared to other SCFP drivers, *sustainability* was found to have the least effect on SCFP in NLNG systems based on group decision-making.

5.10 Confirmation and validation of study phase two findings

To minimise bias and enhance the quality of this study, a summary of study phase two results was shared with LNG supply chain professionals at NLNG for validation. Experts upheld that these findings are relevant and will make a positive contribution to SCFP in NLNG systems. However, the professionals made a recommendation for the researcher to provide additional clarifications regarding *sustainability* strategy. The experts' recommendation was considered and addressed in this research. An improved copy of the executive summary was shared with respondents at NLNG, which they found consistent and significant to SCFP in NLNG networks (Appendix 16). In addition, study phase two findings were presented to industry leaders at the Small-Mid Scale LNG Summit for further validation. Relevant LNG supply chain practitioners confirmed all the key findings (Figure 5.4-5.8; Appendices 11-15).

5.11 Summary of chapter five

This chapter assessed the SCFP capabilities in NLNG systems. In this chapter, SCFP drivers and measures established in study phase one are measured in NLNG systems using quantitative survey data collected from experts at NLNG. The assessment was conducted using AHP to measure the relative weight of each of the identified SCFP capabilities on NLNG SCFP. Analysis of group decision-making reveals *revenue growth* and *cost reduction* as the first and second most important factors for consideration when measuring SCFP in NLNG systems respectively. AHP analysis also identified *integration and collaboration* as the most important driver of financial performance in NLNG systems, followed by *sourcing strategy,* and *IT and automation*. Findings establish *sustainability* as the least ranking driver of SCFP in NLNG networks. Findings from this chapter suggest that *optimal levels of integration and strategic feedgas sourcing* initiatives are essential to realise the full financial advantages of effective supply chain strategies in NLNG systems. However, collective analysis for key divisions at NLNG as sub-groups reveal different variation in priorities, which could be attributed to the nature, roles, challenges and objectives of each division.

Analysis of supplementary Likert-scale data revealed key factors that influence SCFP strategies in NLNG systems, including cost effectiveness, reliability of delivery, trust, knowledge sharing, information flow, health and safety agenda, brand reputation and other environmental and social considerations. The next chapter analyses empirical data using template analysis to develop a taxonomy and to propose a framework for improving financial results in NLNG systems.

Chapter six: Qualitative analysis

6.1 Chapter six overview

This chapter analyses empirical qualitative semi-structured interviews conducted in study phase three (Appendices 4; 17; 18), to access tacit expert knowledge, experience and understanding of SCFP capabilities in NLNG systems, to develop a taxonomy that defines SCFP in NLNG systems and to propose strategies and policies to improve SCFP in NLNG systems (Objectives 5; 6).

Interviews were conducted individually with identified supply chain strategy experts and key decision-makers at NLNG, to extend study phase two findings, by acquiring latent information relevant to SCPF in NLNG systems, which were analysed using template analysis. Template analysis validated some of the findings in study phase one and two (Chapters 3; 5) and established additional SCFP drivers specific to NLNG networks, to develop a taxonomy and propose strategies and policies to improve SCFP in NLNG systems (Objectives 5; 6).

Results from the final template facilitated the development of a dynamic conceptual framework and an explicit taxonomy of SCFP in NLNG systems, assisting proposals of SCFP strategies and policies to guide operators within NLNG supply chains in the design and implementation of SCM strategies.

6.2 Study phase three: Template analysis in NNLG SCFP

In this section of the analysis, interview data relevant to SCFP strategies, including the characteristics and objectives of NLNG distribution systems (Objectives 1; 2; Chapter 2) are analysed using template analysis to develop a framework and an explicit taxonomy of SCFP in NLNG systems based on expert opinion.

6.2.1 Interview response rate

It was extremely difficult to secure interview access with target professionals due to sensitivity and demanding work responsibilities in the LNG industry. However, access was granted for TBEIs through the gatekeeper seven months after the initial contact and subsequent email reminders. Interviews were conducted until saturation was reached where enough data was gathered and there was no new information emerging (Creswell and Poth, 2018). A total of 15 experts responded in just over three months, between March, 2018 and June, 2018. All responses were considered for template analysis of SCFP in NLNG systems. The 15 respondents are from a wide range of managerial levels across diverse business divisions involved with SCFP strategies in NLNG systems, including MD, Deputy MD, Finance, Production, Shipping and External Relations divisions.

6.2.2 Initial empirical template for SCFP in NLNG systems

During template analysis a coding template is developed, typically based on a sub-set of data, which is subsequently revised and refined as further data emerge (Brooks *et al*., 2015). Themes for the initial template were derived from a sub-set of interview transcripts (King and Brooks, 2017). Themes are presented at different order levels to achieve the study objectives and address the research question (Brooks *et al.,* 2015). In this study, categories span from two to five levels depending on the breadth of a group. Initial higher-order themes or top level themes of factors that drive financial performance in NLNG systems included *feedgas supply, IT and automation, integration and collaboration, investment,* and *sustainability.* Four of these higher-order themes are similar to the findings of study phase one; however, *investment* emerged as a new higher-order theme explicit to the case of NLNG SCFP (Table 6.1). Investment strategy entails purposive planning to attract investment into NLNG supply chain, which will enhance production capacity, competitiveness and financial performance. The initial empirical template further reveals *cost minimisation, working capital efficiency, asset utilisation* and *revenue growth* as measurement criteria for SCFP in NLNG systems. This validates study phase one findings, which indicates the same measurement criteria as higher-order themes (Table 6.1; Appendix 17).

Table 6. 1: Study phase one and initial empirical template compared

Study phase one findings	Higher-order themes for initial empirical template
Sourcing strategy	Feedgas supply
IT and Automation	IT and Automation
Integration and collaboration	Integration and collaboration
Sustainability	Sustainability
	Investment

Source: Author

6.2.3 Final empirical template for SCFP in NLNG systems

After identifying base drivers and measures for SCFP in NLNG systems from the initial empirical template, further SCFP data items from interview transcripts were applied to develop the final empirical template. Iteratively modifications were made where weaknesses appeared relating to how well data was captured, relevant and potentially important towards proposing strategies and policies to improve SCFP in NLNG systems (King and Brooks, 2017). The final template for SCFP drivers in NLNG systems has introduced new sub-themes and modified a majority of the initial sub-themes. This iterative process resulted in modification of *capacity development* as a second-order theme in the initial empirical template to a higher order theme in the final empirical template (Appendices 17; 18). *Capacity development* capability involves implementation of clearly defined policies and procedures for hiring, training and retention of labour force with relevant skills across all NLNG value chains. *Capacity development* improves labour productivity and competitiveness and financial performance. The final template for SCFP measurement criteria in NLNG systems has iteratively introduced new sub-themes and modified a few of the initial sub-themes. However, the higher-order SCFP measures in NLNG system remained as *cost minimisation, working capital efficiency, asset utilisation* and *revenue growth* (Table 6.2; Appendix 18).

Table 6. 2: Comparison between initial and final empirical templates

Higher-order themes for initial template	Higher-order themes for final template
Feedgas supply	Feedgas supply
IT and Automation	IT and Automation
Integration and collaboration	Integration and collaboration
Sustainability	Sustainability
Investment	Investment
	capacity development

Source: Author

6.3 Analysis and discussion of key qualitative findings

The final empirical template (Appendix 18) identified *feedgas supply, IT and automation, integration and collaboration, sustainability, investment and capacity development* as higher-order themes that drive SCFP in NLNG systems. *Sourcing strategy, IT and automation, integration and collaboration* and *sustainability* remain similar to the findings of study phase one. However, the term *feedgas supply* espouses *sourcing strategy* as an industry terminology for feedstock sourcing*. Investment and capacity development* are new higher-order themes, which developed as further data emerges from empirical template analysis. The emergence of *capacity development* as a key theme for SCFP in

NLNG systems was not surprising due to the relevant knowhow required to operate in such a specialist and sophisticated automated supply chain network. Further, although extant literature does not categorise *investment* as a SCM capability (Study phase one), *investment* is synonymous with LNG systems due to the highly capital-intensive nature of the supply chains (Werner *et al.* 2014; Hartley *et al.,* 2013; Berle *et al.,* 2013; Greenwald, 2006). The liquefaction component of LNG supply chain which is at the core of the NLNG value chain is the most capital intensive, with key risks facing liquefaction projects including completion risk, supply risk, market risk, pricing risk and political risk (Sousa and Flippen, 2005). This section presents empirical findings rather than generalised conclusions because the results were derived from data collected from NLNG as a case study which was analysed using template methods. However, some of the key findings (Table 6.2; Figure 6.1) are applicable to other major LNG exporting countries.

6.3.1 Feedgas supply as a driver of SCFP in NLNG supply chains

Template analysis established *sourcing of feedgas* as a higher-order theme for SCFP in NLNG systems. A respondent lamented that "…*sourcing of feedgas is one of the major factors*" that cause slow growth in terms of LNG production and export capacity by NLNG networks. This reciprocates study phase one findings where sourcing strategy emerged as a higher-order theme for SCFP. In conformity with TCE, efficient supply chain sourcing strategy should lead to improved financial performance because it allows supply chain partners to focus on their key competitive advantages, which result in win-win situations for all participants (Shi and Yi, 2013). There is strong support for the relationships between strategic purchasing and supply management and financial performance (Chen *et al.,* 2004). Although study phase one established the influence of strategic sourcing to SCFP, empirical findings revealed that the impact of *feedgas supply* could have more propound influence in NLNG SCFP than other competing supply chains. This is largely due to the challenges facing NLNG *feedgas supply* network, especially reported cases of GTS sabotage by third parties, which poses serious threat to security of *gas supply.* These bottlenecks further explain why study phase two ranked *sourcing strategy* as the second most important driver of SCFP in NLNG systems. Eighty percent of respondents posited that security of gas supply is the major factor affecting reliable *feed stock delivery*, which has a significant influence on *cost, revenue, assets utilisation* and *working capital.* A respondent identified that *"…poor security situation leads to higher cost of procurement of goods and services as well as feed stock. Suppliers are limited in number due to high security costs, such as insurance. This leads to frequent outages of logistics services, with its attendant impact on ability to meet demand".*

Empirical findings revealed that reliability and timely supply of feedgas affect planning and demand management, which results in plant down time, tank tops and failed deliveries, all of which has serious reputational, legal and financial performance metrics concerning *costs, revenue* and *assets utilisation* to NLNG distribution systems. Results indicated that limited number of *feedstock* suppliers also affect NLNG SCFP in terms of competitive pricing and supply options, especially when a key supplier is faced with production or delivery holdups. Flexibility in gas supply sources will inhibit this problem. Another challenge to NLNG sourcing strategy is absence of specific pricing mechanism for feedgas, considering feedgas is the major direct *cost* in NLNG distribution systems. In addition, findings established that robust contracting and procurement system for associated materials, consumables and spares is necessary to *optimise working* *capital performance* in NLNG supply chains. This involves information sharing and collaborating with suppliers in areas of procurement, outsourcing and warehousing. Supplier *collaboration and integration* is integral to *sourcing strategy* because it facilitates reliable delivery (Lee *et al.,* 2007). *Strategic sourcing* can stimulate sustainable competitive advantage by enabling companies to develop close working relationships with suppliers, promote information sharing, and build long-term strategic relationships to achieve mutual benefits (Chen *et al.,* 2004).

However, findings from study phase one established that to improve financial performance, *costs* of implementing a certain *sourcing strategy* should not outweigh its benefits. *Sourcing strategy* is concerned with how supply chain companies constantly evaluate the *costs* of make-or-buy decisions (Shi and Yu, 2013). Decisions to make positively affect internal performance metrics concerning *costs* and *asset utilisation.*

Proposition nine: *Cost effectiveness and reliable “feedgas supply” in NLNG supply chains does not only drive financial performance, but also has the ability to shut the NLNG networks. It is proven that challenges to “feedgas source” can lead to shutdown of the entire NLNG supply chains. Analysis revealed that to improve sourcing strategy and enhance SCFP in NLNG systems, strategy should consider the possibility burying pipelines deeper in addition to incorporating necessary surveillance and security measures to mitigate against third party sabotage. Consistent with study phase one findings, “feedgas sourcing strategy” makes positive contributions to SCFP in NLNG systems. “Feedgas supply” is more efficient when there is collaboration and integration with suppliers.*

6.3.2 IT and automation as a driver of SCFP in NLNG supply chains

Table 6.2; Appendix 18 depict *IT and automation* as higher-order NLNG SCFP theme. This is consistent with study phase one findings that equally established *IT automation* as a key driver of SCFP. In conformity with RBV, efficient *IT and automation* strategy allows supply chain partners to utilise their technological capabilities to improve financial benefits across NLNG systems. *IT-based* SCM systems make positive contributions to financial performance (Dehning *et al.,* 2007). However, analysis implied that the influence of *IT and automation* in NLNG SCFP is not as significant as that of *investment, sourcing strategy* and *integration and collaboration.* Findings revealed that the performance of *IT and automation* is heavily influence by *investment, supply chain integration* and *knowledge base* across NLNG supply chains. This further validates study phase one findings that financial performance from supply chain *technology investments* are derived from improvements in *knowledge-intensive capabilities*, which result in improved operational capabilities. Further, the ability to realise the impacts of supply chain *IT and automation* capabilities on financial performance are influenced by external economic factors (Blankley, 2008).

LNG networks are highly automated with state of art technologies embedded across the entire value chains. A vast majority of NLNG capital outlay is invested on *IT and automation* infrastructure. Liquefaction trains are key *automation and technological* components of any mid-stream LNG operations like NLNG. Capacity of output produced by any LNG exporter is influenced by the size and reliability of its liquefaction trains. However, a major challenge is *investment* requirement for capacity expansion and maintenance, as liquefaction is the most capital-intensive value stream. Another major NLNG value chain that is fully automated is shipping. NLNG utilises both own vessels and fleet of LNG ships which are dedicated to NLNG under long-term charter agreements. Analysis revealed that the ownership of LNG vessels has influence on control of outbound logistics and *cost effectiveness* of shipping system. A respondent identified that "…*control of outbound logistics is also a factor affecting"* LNG SCFP. Findings revealed that *IT and automation* strategy improves financial performance in NLNG supply chains by facilitating replacements of aging assets, which improve the condition and performance of the plant due improved asset reliability, integrity and utilisation. NLNG (2016) postulated that high fleet reliability of 98.4% as one of the factors that resulted into its shipping performance in 2015. Automation strategy encompasses plant, terminal and vessel maintenance plans, which enable service delivery to meet NLNG's customer expectation. Results indicated that construction complexities peculiar to LNG supply chains hinders the speed and rate infrastructural development required to fully optimise SCFP in NLNG systems.

According to TCE, *IT and automation* improves supply chain *collaboration and integration*, and minimise administration and coordination *costs* (Shi and Yu, 2013). Similarly, template analyses established that *IT and automation* facilitate *supplier integration*, which in turn enhances SCPF in NLNG systems. A supply chain expert at NLNG identified that *"… partnering with supplies including operations integration using information technology"* enhances SCFP in NLNG systems. IT and electronic information sharing are associated with overall supplier performance satisfaction (Field and Meile, 2008). Results revealed that the performance of *IT and automation* is heavily influence by *investment*, *supply chain integration* and *knowledge base* across NLNG supply chains. This explains why study phase two ranked *IT and automation* as the third most important driver of SCFP in NLNG system. However, *IT and automation* has significant influence on all the other drivers, especially on *integration and collaboration*. There is direct positive relationships between *IT integration* and *supply chain integration*, which is an enabler for customer service, which in turn directly influences financial performance (Vickery *et al.,* 2003). *IT platforms* enable information trade and financial flows, and advanced technologies such as blockchain and artificial intelligence will have a significant influence on the development and impacts of SCF in multi-national supply chains like NLNG networks. There are growing numbers of on-going studies regarding application of new technologies in SCF. *New technologies* will foster the coordination in buyer-supplier relations and eliminates existing inefficiencies in the application of SCF instruments, *optimise cost*, improve cash flow and enhance business sustainability and growth (Templar *et al.,* 2018; Omran *et al.,* 2017).

Proposition ten: *"IT and automation" influence SCFP positively. The levels of investment, knowledge base and supply chain integration facilitate technology adaptation and implementation. "IT and automation" enables supply chain integration and service delivery, which in turn drives financial performance in NLNG systems. The capacity of technology especially in terms of liquefaction trains and LNG vessels determines the volume of LNG that can be channelled downstream to realise revenue for NLNG supply chain. Analysis revealed that to improve the performance of "IT and automation" strategy and enhance SCFP in NLNG systems, strategy should attract investment needed for additional LNG trains, including NLNG 7 and 8, as well as other greenfield project such as the Brass LNG in Bayelsa State. In conformity with study phase one findings, "IT and automation" makes positive contributions to SCFP in NLNG. "IT and automation strategy" is more achievable when backed by required investment and technical* *skills, and is more efficient when there is collaboration and integration within and across NLNG supply chains*.

6.3.3 Integration and collaboration as a driver of SCFP in NLNG networks

According to TCE and RBV, study phase one results revealed that *integration and collaboration* as the dominant SCFP driver (Zhao *et al.,* 2015; Shi and Yu, 2013). Similarly, study phase two also ranked *integration and collaboration* as the most important driver of SCFP in NLNG systems. Study phase three established that although *integration and collaboration* influences SCFP in NLNG networks, it is not as dominant as *investment* and *sourcing strategies*. The variance in findings was largely due to the challenges facing NLNG's *feedgas sourcing* and *investment strategies* (Sections 6.3.1; 6.3.4), due to country socio-economic and political challenges. Another reason for the discrepancy between study phase one and empirical NLNG study findings is that unlike other manufacturing or service industries that a majority of SCM authors studied, the oil and gas industry and in particular all the major LNG supply chains including NLNG are extensively integrated. For example, NNPC, Shell, Total and Eni own NLNG, it has long-term *feedgas supply* agreements with Shell, Total and Eni, and distribute LNG using its wholly owned shipping subsidiary, BGT. Another wholly owned subsidiary of NLNG is Nigeria LNG Ship Manning Limited (NSML) provides, develops and manages *personnel* to man NLNG vessels. NLNG has 10 buyers under LTCs, amongst which are ENI, Shell, and Total (NLNG, 2018b). This extensive vertical integration has made *integration and collaboration* effective in improving SCFP in NLNG logistic networks.

Findings established that *integration and collaboration* enhances SCFP in NLNG systems by facilitating supplier partnership, which enhances *flexibility in gas supply*. A respondent at NLNG identified that "… *greater partnering with supplies including operations integration using information technology"* is a strategy that can enhance SCFP in NLNG systems. This is associated with lead-time reduction, demand management, service delivery, spot sales opportunities … *especially in periods of demand or supplies uncertainties*. In addition, IT based integrated operation partnership with suppliers improves financial results in NLNG supply chains. Empirical results revealed *integration and collaboration* improves NLNG SCFP through communication dissemination across NLNG system. Information sharing has favourable effects on financial performance for supply chain partners in terms of sales growth, sales productivity, and profitability, and enhance the likelihood of distributor contract renewal (Schloetzer, 2012). Similarly, *integration and collaboration* facilitates LTC that have the benefits of take-or-pay provision for NLNG because LTC secure product sales and SCF stability and sustainability for NLNG systems. Further, unlike spot contracts, LTC enhance opportunities for project finance, and protect the huge initial *investment outlay* of an LNG supply chain, however, LTC do not provide much flexibility like spot contract to take advantage of arbitrage opportunities, as well as to satisfy customers in periods of excess demand. A mixture of both LTC and spot contracts is necessary to optimise SCFP in NLNG networks. Supply chain experts at NLNG identified that:

> *"LTC guarantees future revenue streams but limit opportunities of upside in spot arrangement. LTC is key to investment decisions in LNG ventures due to the capital intensive nature of the business". "The benefits of LTC is to secure the sales of the products before production and thus enhancing opportunities for securing credit. The drawbacks has to do with adjusting to the volatile LNG market pricing. "…spot sales however provide more*

> *flexibility to earn more sales revenue from product especially in period of unbalanced demand/supply or constrained supply market".*

Integration and collaboration facilitates risk sharing between supply chain partners, which enhances SCFP in NLNG systems. *Integration and collaboration* is an enabler of internal integration, which enhances information flow and utilisation, as well as access to material and inventory management. *Information integration* positively affects business performance with greater impacts when is operated under a highly complex market environment (Wong *et al.,* 2015). *Internal information integration* is positively related to service quality, which has positive impact on financial performance (Huo *et al.,* 2016).

Empirical findings established that *integration and collaboration* affects SCFP in NLNG systems. *Supply chain integration and collaboration* improves supply chain flexibility, which helps in addressing uncertainties and glitches in supply chains to enhance financial benefits (Germain *et al.,* 2008). Results revealed that flexibility provides *cost competiveness* to the supply chain and *reduces cost* of goods, materials and services. Template analysis revealed that in LNG supply chains, *integration and collaboration* attracts *investment* in form of mergers and acquisitions, and JVs. Trust is particularly important to manage external relationships. Trust with customers and suppliers significantly influences *supply chain integration* and consequently improves financial performance (Zhang and Huo, 2013). Findings established that trustworthiness facilitates access to finance, sanctity of agreements and commitments from NLNG investors. Study phase three established that *investment* is the major financial performance driver in NLNG system and not *integration and collaboration* (7.3.4).

Proposition eleven: "*Integration and collaboration" consisting of internal integration, as well as up and down streams "integration and collaboration" with* *feedgas suppliers and customers is necessary to optimise SCFP in NLNG distribution system. "Integration and collaboration" enhances financial performance metrics including revenue, cost, and profitability in NLNG networks. "Supply chain integration and collaboration" fosters supply chain flexibility, which enhances financial benefits especially during market unpredictability. However, the performance of supply chain "integration and collaboration" in NLNG supply chains could be affected by the level of IT and automation as well as investment strategies. Further, mutual trust between NLNG supply chain partners has significant influence on integration and financial performance, especially in terms of LTC, access to finance and commitments by investors in NLNG systems.*

6.3.4 Investment as a driver of SCFP in NLNG supply chains

Investment is a new higher-order theme for SCFP in NLNG systems that emerged from empirical template analysis. This could be attributed to the argument that *investment* is not regarded as SCM capability in theory. However, the capital-intensive nature LNG supply chains, as well as the *investment challenges* facing the NLNG has made *investment* the dominant higher-order theme because of its impact on NLNG SCFP as well as on other SCM capabilities, especially *IT and automation, capacity development* and *sustainability.*

Empirical results established that project economic viability is a major concern for *investors* in NLNG supply chains. NLNG project economic feasibility is influenced by market volatility and economic conditions such as low crude oil price which LNG price indexed, for example, the JCC, affects price stability and *revenue* of NLNG supply chain participants. Low gas prices continue to place pressure on the development of new projects, with only a handful of projects receiving FIDs since the gas price downturn in mid-2014. Another factor affecting the LNG market is competition due to rapid growth of key competitors such as Australia and Qatar, as well as emergence of new exporters like the US and Angola. Rise in gas production and fast growth in LNG liquefaction capacity continues to exert pressure on LNG prices (Clarksons, 2017). A respondent identified that *"low crude oil prices to which LNG price is linked…* and *…global oversupply of LNG…"* are some of the factors that cause slow growth of LNG production and export capacity by NLNG. Further, growth of alternatives energies and distance to major importers especially Japan, India and Korea are concerns for *investors* in NLNG supply chains.

Template analysis has established that the ability for NLNG to secure LTC has influence over its economic viability and *investment opportunities*. The take-or-pay clause in LTC guarantees stable cash flow along the NLNG distribution systems, which offers security for investors across NLNG value chains. The take-or-pay arrangement offers a platform for improved operational and cash planning which enhances SCFP in NLNG systems. A supply chain professional at NLNG asserted that "…*with LTC, economic viability of a project is clearer from the onset. There is greater stability along the supply chain. …take-or-pay arrangements …offers more security across board. LTC arrangements also provide platform for better operational and cash planning with more predictable financial performance*". In addition, LTC improves economic viability of an LNG project because it reduces *financing costs* and enhances opportunity for project finance for the high capital outlay. However, LTC does not provide much flexibility like spot contracts. *"LTC allows for long gestation of the business and recouping of huge outlay"*, a respondent stated.

Findings revealed that the level upstream *investment* in feedgas production affects NLNG economic viability and *investment*, because it determines the level of feedstock sent to NLNG liquefaction facility for processing. An expert identfied that "… *weak upstream investment in feedgas production to serve new plants"* is a factor that may prevent investors from LNG investment in NLNG supply chains.

Empirical results established that socio-economic factors such as political stability, government policies and regulatory requirement are major determinants for *investment* in NLNG networks. Respondents unanimously indicated that the political instability in the country, especially the security risks in the Niger Delta region have an extensive impact on NLNG SCFP. These security threats are severe and come in different forms. They include social menaces such kidnappings within the Niger Delta and piracy activities offshore. The security situation also causes economic losses, such as GTS vandalism, which threatens *feedgas supply*, production, services delivery and *revenue*. GTS sabotage also has impact on *assets utilisation* because it could bring halt production and renders the entire asset of NLNG unproductive. Further GTS leakage has *cost* impacts in terms of repairs and maintenance after any third party sabotage, which has tremendous influence on SCFP in NLNG systems. Threats to both life and property has also resulted in high insurance *costs* for both personnel and assets, this negates NLNG supply chain competitive advantage. The security situation in the region has stalled *investment* in the country's LNG industry. This is arguably one of the major reasons that lead to cancellation OKLNG, delays in Brass LNG and NLNG train 7 projects analysed in Chapter 2. An expert at NLNG identified that *"…stability and sustainability of supply, reserve issues, security concerns, environmental and regulatory framework"* are amongst the challenges affecting investors from *investment* in NLNG supply chain.

Another socio-economic factor that influences *investment* as a driver of SCFP in NLNG systems are policies and regulatory requirements. Policies such as meeting domestic gas demand before exports affects NLNG SCFP especially in periods of high prices and demand globally. The desire to meet domestic gas demand also affects the ability of NLNG to secure profitable LTC and improves its SCFP. Fiscal regimes such as taxes, levies and subsidies are also key economic factors that influence *investment* in NLNG supply chains. *Investors* are sceptical about possible changes to the current pioneer tax incentives when the long awaited all-encompassing Petroleum Industry Bill (PIB) is implemented. The PIB is currently broken down to smaller bills such as the Petroleum Industry Governance Bill (PIGB) and Petroleum Industry Fiscal Bill (PIFB). FIGB will establish among other things a fully independent petroleum regulator, and a new NOC to be run independently and on a fully commercial basis (KPMG, 2017). The PIFB is the latest fiscal iteration in the decade-long reform and restructure of Nigeria's petroleum industry that highlights significant shifts in fiscal policy (Petroleum Industry Fiscal Bill, 2018). In addition, corruption and delays in clearing of goods have been cited as socio-economic factors that affect *investment* in NLNG supply chains. A respondent lamented that *"corruption, unfavourable business environment, external/community relations issues"* are some of the challenges affecting investors from *investment* in some LNG exporting countries.

Results established that access and *cost* of project finance has a major influence on NLNG *supply chain investment*. Conditions such as stringent requirement for counterpart funding, *cost* and return on investment, mergers and acquisitions, country credit rating, and desire for risk sharing have significant impact on *investment* as a key driver of SCFP in NLNG systems. Marketing strategy was also found to have effect on *investment* as a key driver of SCFP in NLNG networks. Marketing of NLNG supply chains facilitates JVs and commitments from *investors,* which have impact on SCFP in NLNG networks.

Proposition twelve: *Although "investment" is not regarded as one of the key SCM capabilities in theory, "investment" emerged from empirical interview findings as a major driver of SCFP in NLNG distribution systems, largely due to the capital-intensive nature of the industry as well as country peculiarities specific to NLNG networks. In addition, "investment" is the most dominant higher-order theme because of its substantial influence on other SCM capabilities, especially IT and automation, capacity development and sustainability. NLNG project feasibility, including market conditions, contracts and access to feedstock is a determinant for "investment" into NLNG supply chains. Further, Socio-economic factors such as political stability, and policies and regulatory requirements should be considered when developing an "investment" strategy to drive SCFP in NLNG logistics systems. It was established that access and cost of financing as well as marketing strategy also has influence on NLNG "investment".*

6.3.5 Sustainability as a driver of SCFP in NLNG supply chains

Template analysis identified *sustainability* as a higher-order theme for SCFP in NLNG systems. A number of respondents posited that *sustainability* is one of the major components of SCFP in NLNG networks. However, similar to study phase one findings *sustainability* is not one of the dominant drivers that emerged from template analysis as a higher-order theme for SCFP in NLNG systems. *Sustainability* strategy in NLNG supply chains encompassing environmental and social capabilities, while simultaneously aiming for financial benefits have a significant impact for NLNG SCFP and survival in a risky and competitive energy market. Empirical studies revealed that the social aspect of sustainable NLNG supply chain includes a robust security framework that addresses social security challenges such as onshore kidnappings and offshore piracy activities. Another safety aspect of social strategy is the HSSE culture, which if adhered to will result in long-term financial benefits. An effective social *sustainability* agenda ensures that all operational activities are underpinned by HSSE principles that continually seek improvements in the safe and sustainable *utilisation of assets* to achieve ultimate financial outcomes in NLNG supply chains. Further, results established that community relation issues, such as host community development programs are drivers of NLNG *sustainability* agenda. As part of its CRS, NLNG is funding a social development initiative to meet the work force requirements of companies operating on Bonny Island, promote acquisition of vocational and entrepreneurial skills and development of technical competences and self-reliance in youths of Bonny Kingdom. In addition, NLNG is involved in local infrastructural development with activities ranging from electricity generation, road construction and repairs to water supply as well as building and furnishing of schools and health centres (NLNG, 2018b).

Analysis established that environmental considerations are key to NLNG supply chain *sustainability* agenda. The entire LNG value chains contain certain element of environmental risk due to chemical composition of natural gas, factory pollution, GTS leakage and maritime pollution. *Sustainability* in supply chains is more effective when implemented jointly by all supply chain participants. The oil and gas industry is highly regulated locally and internationally to safeguard the environment. Increasing attention on supply chain *sustainability* reflects concern with climate change and ecosystems, which necessitate environmentally friendly practices as a competitive supply chain strategy, in turn impelling companies to integrate environmental performance as an integral driver of financial performance (Ntabe *et al.,* 2015). Robust GTS security plan is necessary for NLNG logistics systems to minimise environmental *costs* associated with GTS leakage. This will also help address some of the host community concerns about NLNG supply chain activities. Similarly, continuous compliance with NLNG HSSE framework and international standards such as ISO14001 are essential towards achieving sustainable SCFP in NLNG system.

Empirical findings conformed to results from study phase one indicating that sustainable operation is *costly*, however, the *cost* of non-compliance is severe. Unethical or lax practices can be catastrophic in the oil and gas industry. For example, in January 2018, it was announced that BP is to take a further USD 1.7B charge related to the Deepwater Horizon oil spill, bringing the total *cost* above USD 65B, as the 2010 disaster continues to weigh on the company's finances eight years after the incident (FT, 2018). Likewise, in January 2013 Shell was held liable in The Hague for oil pollution in the Niger Delta of Nigeria (Hennchen, 2015). To avoid similar tragedy and enhance SCFP, NLNG is a member United Nations Global Compact (UNGC), a declaration of its continued commitment to incorporate environmental, social and governance standards in its strategies, policies and procedures, as well as embed culture of integrity (NLNG 2018b: 20).

Results have shown that it is essential to address the security condition to improve *sustainability* and optimise economics performance in NLNG systems. Dealing with the security challenges will not only reduce maintenance *cost*, but also will improve reliability of feedgas supply, minimise downtime, enhance *assets utilisation*, and improve LNG shipment, increase customer satisfaction and *revenue* across NLNG logistics networks. Study phase one revealed that there is an increasing social and environment awareness globally, not only by host communities but also by other stakeholders including customers. Analysis supported this assertion that *sustainability* is essential in meeting customer expectations and facilitates securing of LTC. *Sustainability* strategy that drive SCFP in NLNG networks incorporates technological innovations in the form of state of the art liquefaction trains and low emission LNG vessels.

Proposition thirteen: *Social and environmental “sustainable” NLNG supply chain practices have positive influence on the economic dimension of “sustainable” NLNG systems, which has strong financial impacts. “Sustainable” practices in NLNG systems have cost implications, however, the cost of non-compliance far outweighs any savings that could be made, which is very detrimental to long-term financial performance. “Sustainability” in NLNG networks is more efficient when implemented across all value streams. Investment, knowledge-base and technology enables of “sustainability” in NLNG systems and it supports NLNG supply chain to meet customer expectations, which drives competitive advantage and SCFP.*

6.3.6 Capacity development as a driver of SCFP in NLNG networks

In conformity with KBV and RBV, study phase one established that *knowledge-intensive capabilities* are SCM practices that drive financial performance by enhancing technology implementation as well as integration of supply chain knowledge and strategies. However, study phase one does not categorise *capacity development* as a higher-order theme. For instance financial performance from supply chain IT investments are derived from improvements in *knowledge-intensive capabilities*, which result in improved operational capabilities (Blankley, 2008). *Capacity development* is another new higher-order theme for SCFP in NLNG systems that emerged from empirical template analysis (Appendix 18). *Knowledge or capacity development* is a major driver of SCFP in NLNG systems. This is attributed to the dynamics of NLNG supply chain operations such as the level of technologies involved, capital requirements, regulations, integration intensity, and in addition to environmental and community relations. Efficient supply chain *knowledge and competencies* include general knowledge, specific logistics/SCM knowledge and competencies/skills (Mangan and Christopher, 2005: 187). Empirical findings have shown that *supply chain knowledge* has positive impacts on NLNG SCFP as well as on all other higher-order SCFP drivers.

Template analysis established that retention of *knowledge base* and sustained *capacity development* improve SCFP in NLNG distribution systems. The CEO of NLNG identified that "…*collective commitment… of our diversified and talented people… has been instrumental to the sustained success and improvement of our corporate performance*" (NLNG 2018a: 22-23). *Knowledge* of organisational culture also drives NLNG SCFP. Findings revealed that security challenges threaten *capacity development* by making it difficult to attract expatriates with the required skills needed to improve SCFP in NLNG supply chains. An LNG supply chain expert lamented that *"security challenges are potential show stoppers as they affect both material and human assets which has a consequential effect on production. Also associated costs of provision of mitigations for security issues and difficulties in securing the services of expats… ".* Effective *knowledge-intensive capabilities* facilitate local content development, which is at the top of the NLNG agenda to develop indigenous capacity with relevant skills and expertise to operate efficiently across all NLNG value streams.

In line with the Nigerian Oil and Gas Industry Content Development Act (NOGICD) 2010, NLNG established schemes such as the Nigerian content commitment project. The Nigerian content includes major initiatives such as the training and development of Nigerians in various aspects of ship design and construction, supply of materials and feasibility studies for the establishment of a dry-docking and ship-repair yard in Nigeria (NLNG, 2018b: 29). Motivation in learning process is necessary for NLNG to optimise its training strategy. Tang and Sampson (2017) proposed enabling factors for new shipboard technologies, including establishing a *positive learning environment*; adopting clear policies; allowing seafarers to identify their own training needs and allowing seafarers to request support for specific courses. *Capacity development* and its retention will provide a skilled labour force, employment to Nigerians as well *reduction in cost* of expatriates in the long-run. Some respondents identified that *"…employment … for teeming youths with restive potentials"* as well as *"retention of knowledge base and sustained capacity development of human resources"* are strategies that can enhance SCFP in NLNG systems.

Proposition fourteen: *"Capacity development" influences SCFP positively. The levels of investment, technology implementation, integration intensity, environmental conditions and availability of skilled labour facilitate "capacity development" and retention. Further "capacity development" enables other NLNG SCFP drivers such as investment, supply chain integration, technology implementation and utilisation, and sustainability. NLNG supply chains involve complex and risky operations such as staffing of liquefaction trains, terminal operations and ship handling, which all need a certain level of expertise to operate safely and efficiently to improve financial performance across NLNG supply chain systems. "Capacity development" and retention facilitates internal* *integration as well as external integration with suppliers and customers, which enhances flow of information, material and finance within and across NLNG supply chain networks. The level of integration and collaboration influences the reliability of feedstock as well as the volume of LNG that can be channelled downstream to realise revenue for NLNG supply chain participants. "Capacity development" initiative should make provision for appropriate recruitment and training policies and funding to enhance SCFP in NLNG systems. Template analysis revealed investment as the dominant SCFP driver in NLNG systems and established that "capacity development" attracts investment into NLNG networks.*

6.4 Divisional comparative findings for SCFP drivers

Similar to study phase two findings, sub-group analysis regarding the influence of key SCFP drivers varied based on divisional perspectives and objectives, including the MD, Finance, Production, and Shipping divisions respectively. First, analysis of responses from the MD division has shown *capacity development, sourcing strategy* and *IT and automation* as the dominant drivers of SCFP in NLNG systems. Second, findings from the Finance division established *capacity development, sourcing strategy, IT and automation, integration and collaboration* and *investment* as the influential drivers of SCFP in NLNG systems. Third, results from the Production division established *capacity development, IT and automation, sustainability* and *investment* as the key drivers of SCFP in NLNG systems. Lastly, analysis from the Shipping division established *sourcing strategy, IT and automation, integration and collaboration* and *investment* as the dominant drivers of SCFP in NLNG systems.

6.4.1 Influence of SCFP drivers from the Managing Director division

The collective response from experts in the MD division regarding SCFP drivers in NLNG systems reveals that the SCM initiatives were given relatively different priorities when compared to the overall analysis of responses from the entire respondents at NLNG.

Practitioners from the MD division of NLNG describe the key factors of SCF in the LNG industry as *"…feed gas price, assets maintenance costs, shipping costs, port charges and inventory costs, …cost of funds and risk sharing".* The respondents further identified *"operating costs, taxes and levies, products prices, production capacity, plant availability and reliability, liquidity, sustainability, …profitability and HSE"* as the components of SCFP in the LNG industry. Further, analysis established that *cost* is the most influential measuring criteria for any SCFP strategy in NLNG networks. This differs slightly from study phase two results where *cost* was ranked second behind *revenue* as the most important SCFP measuring criteria in NLNG systems. Respondents also lamented that "*gas supply reliability, asset integrity, costs of spares and consumables, security, shipping cost…, …statutory regulation, fiscal landscape, IT infrastructure, …unstable policies, multiple taxations and corruption"* were the main challenges affecting LNG SCFP. Analysis confirmed the influence of established SCFP drivers, including *sourcing strategy, IT and automation* and *sustainability* in NLNG systems.

"*The slump in crude oil prices to which LNG price is linked, poor projects economic viability due to increase in construction cost, global oversupply of LNG, ...project financing, unfavourable/unstable government policies, lack of adequate tax incentives*" are cited as causes of slow growth in terms of LNG production and export capacity by some major LNG exporting countries. Findings corroborate that although *investment* is not a SCM strategy in theory, *investment* is a driver of SCFP in NLNG networks. "*Unfavourable fiscal regimes in the upstream sector, political risks, excessive taxes and levies, security of gas supply, port safety and marine security, unpredictable regulatory environment and …corruption"* are major factors that may prevent investment in NLNG supply chain systems. Respondents from the MD division further confirmed the influence of supply chain flexibility on financial performance, stating that *"flexibility provides cost competiveness of the supply chain and reduces cost of goods, materials and services"*. The strategies and policies that can enhance LNG SCGFP include *"asset integrity management strategy, flexibility in gas supply sources, contracting and procurement strategy, retention of knowledge base, sustained capacity development of human resources, marketing strategy, cost effective shipping system*" a respondent from MD division suggested. This placed emphases on *feedgas sourcing, IT and automation* and *capacity development* as key drivers of SCFP in NLNG systems measured by *cost minimisation* and *assets utilisation*.

6.4.2 Influence of SCFP drivers from the Finance division

Sub-group response from practitioners in the Finance division regarding SCFP strategies in NLNG systems reveals relative inconsistencies between responses from experts at the Finance division and those from other divisions regarding the key factors of SCF in LNG industry. Practitioners from the Finance division of NLNG identified that *"…feedgas…"* as the most influential inbound logistics and *"…demand management…"* have significant influence on SCF in the LNG industry. Experts further argued that drivers of SCFP in NLNG systems are

"…influenced by the working capital need of the business and available surplus cash".

In terms of the components of SCFP in the LNG industry, experts at the Finance division placed emphasis on supply chain and logistics related costs including *"planning cost, sourcing/procurement cost, transportation and logistics, inventory management cost…, …payment terms and lead time…".* In addition, "*working capital management including advance funding to ensure timely supply of input materials as well as receivables management, provision of information to support decision making around sourcing and inventory management"* are cited as the components of supply chain financial performance in the LNG industry. Similar to the response from the MD division, experts from the Finance division lamented that *"poor planning and demand management, lack of credible/reliable supply sources …unreliable and expensive logistics services, regulatory bottlenecks and … local legislation"*, in addition to *"pricing mechanism for feedgas, relative age/health of the plant, and …ownership of LNG supply vessels"* which affect cost, assets utilisation and profit margins as the challenges affecting LNG SCFP. *"Availability of finance, infrastructural challenges, local legislations, market conditions…, …unfavourable investment climate and …fiscal regime, and inadequate feed stock"* are mentioned as causes of slow growth in terms of LNG production and export capacity by LNG mid-stream supply chains. Experts further lamented that the security situation in the country affects NLNG SCFP to a great extent in terms of the supply chain's ability to mobilise and retain skilled labour, high insurance costs, limited suppliers, country credit rating, pollution cost due to pipeline vandalism, and service delivery.

Participants from the Finance division argued that *"stability of government policies, …legislative/regulatory constraints, slow development of gas reserves, …growth on the world LNG supply, …low Brent prices"* affect the economic viability of new investments in some LNG exporting countries. The strategies and policies that can enhance LNG SCFP identified by an expert from the Finance division include *"better planning and demand management, indigenous capacity development and funding, more friendly fiscal policies…, improvement in infrastructure and logistics support".* Another respondent proposed *"greater partnering with suppliers including operations integration using information technology; …internal collaboration to provide greater visibility on available materials and utilisation data; optimal DES and FOB mix in export sales; increased production capacity through investment in new trains; direct upstream investments in exploration, production facilities and supply lines"*. Analysis of responses from the Finance division established *feedgas sourcing, investment, integration and collaboration, IT and automation* and *capacity development* as key drivers of SCFP in NLNG systems measured by all the four components of EVA: *cost minimisation, revenue growth, working capital* and *assets utilisation*.

6.4.3 Influence of SCFP drivers from the Production division

The collective response from experts in the Production division regarding SCFP drivers in NLNG shows discrepancies between responses from experts at the Production division and those from other sub-divisions regarding the key factors of SCF in LNG industry. Professionals from the Production division identified risk exposure and political stability as key factors that influence SCF in NLNG systems. Respondents from the Production division placed emphasis on *"ROI and sustainability"* as the key components of SCFP in the LNG industry. Experts lamented that unstable policies, market volatility alternative energies, political climate, and security challenges negatively affect LNG SCFP. In addition, *"unclear policies, unstable political systems, project financing, local content capabilities, …changing global economic climate, growth in alternative energies, entrance of other players into the market, price stability and cost of investment, source of funds, …inability to secure long term buyers…"* are the causes of slow growth in terms of LNG production and export capacity by NLNG supply chains. Participants from the Production division also lamented that the factors that may prevent investors from LNG investment include "*political …stability… , cost of investment versus return, economic uncertainties, changes in global business landscape, complex regulatory requirements, mergers and acquisitions, rapid technological evolution, high customer expectations and …community relations issues*".

Experts deplored security challenges that negatively affect SCFP in LNG systems, lamenting that "*security challenges are potential show stoppers as they affect both material and human assets and consequential effect on production…".* As a result of security issues, "*investors are wary* and hesitant *to invest in such countries, …OKLNG, Brass LNG, and NLNG Trains 7/8 are examples"*. The strategies and policies that can enhance LNG SCFP identified by supply chain professionals from the Production division include *"stable policies, investment in basic infrastructures and employment generation, …tax incentives, organisational culture, plant assets (…human, equipment, systems…) availability and reliability* of feedstock*…".* Analysis of responses from the Production division established *investment, capacity development,* and *IT and automation* as key drivers of SCFP in NLNG systems measured by *cost minimisation* and *assets utilisation*.

6.4.4 Influence of SCFP drivers from the Shipping division

Sub-group response from professionals in the Shipping division regarding SCFP strategies in NLNG systems indicates some inconsistencies between responses from experts at the Shipping division and those from other divisions regarding the key factors of SCF in NLNG networks. Analysis of responses from the Shipping division of NLNG revealed *"…information technology and collaboration"* as the major factors of SCF in the LNG industry. Experts further argued that "*information technology*" is the main component of SCFP in NLNG systems.

Findings from the Shipping division established that *"government policies and lack of communication"* are the challenges affecting LNG SCFP. Experts lamented that *"government policies…, gas supply, political environment…, investor confidence and JV politics"* are the reasons for slow growth in terms of LNG production and export capacity by some major LNG exporting countries. Respondents also expressed concern relating to how the security situation in Nigeria affects NLNG SCFP, stating that *"…investors will not be willing to invest, the insurance premium will be high. …If the location is declared high risk, the manning cost increases as a result of high risk compensation to the crew, this is equivalent to 100% of their wages…".* In addition, *"security, political stability, distance to major consumers, …competition and government regulation*" may prevent investors from investing in NLNG supply chain networks. The strategies and policies that can enhance LNG SCFP identified by an expert from the Shipping division include favourable *"government policies, subsidy and tax regimes"*. Analysis of responses from the Shipping division established *feedgas sourcing, investment, integration and collaboration,* and *IT and automation* as the most influential drivers of SCFP in NLNG systems.

6.5 Template findings for SCFP measures in NLNG systems

Empirical findings related to SCFP measuring criteria in NLNG systems established *revenue, cost, working capital* and *asset utilisation* as key SCFP measures in NLNG supply chains (Appendices 17; 18). This conformed to results from study phase one (Figure 3.2; Appendices 1; 2). SCM capabilities have an impact on sales growth, ROE, ROI, ROA, and profit margins (Blankley, 2008). *Revenue* as a component of profitability is an important SCFP measure; it enhances ROI and increases shareholders' wealth due to its impact on earnings per share. Empirical findings suggest that high *revenue* associated with spot sales enhances NLNG SCFP; however, uninterrupted *revenue* streams associated with LTC provide more sustainable financial gains to NLNG supply chains. An expert in NLNG argued that *"LTCs guarantee future revenue streams but limit opportunities of upside in spot arrangement..., spot sales… provide more flexibility to earn more sales revenue from product especially in period of … constrained supply market".* Other respondents also corroborated these assertions that "*LTC guarantee continuity and business sustainability, while spot sales improves revenue and earnings…",* and that LTC "*drawback is associated with inflexible supply and sometimes low profitability due to inability to take advantage of high prices. On the other hand, spot sales can be problematic in getting a buyer, especially when there is a glut but the benefit is that one can take advantage of high prices to increase net profit and revenue*" in periods of high demand. To improve *revenue* generation in NLNG supply chains, strategy should consider a mixture of LTC and spot sales using both DES and FOB to enhance market share.

Results established that GTS vandalism threatens feedgas supply, production, services delivery and *revenue*. A major concern regarding the security situation in the country is that it causes glitch in NLNG supply chains that results in loss of potential *revenue*. Increase in production capacity through *investment* in new trains and production facilities, direct upstream *investments* in exploration and GTS lines, as well as addressing insecurity will have significant influence in *revenue* and financial performance in NLNG supply chains. Likewise, study phase one revealed that companies that experience glitches report on average lower sales growth, and higher growth in *cost* and inventories. Particularly, firms do not recover quickly from the adverse financial consequences of glitches (Hendricks and Singhal, 2005). Study phase one established that extensive process integration and information sharing have favourable financial influences for supply chain partners in terms of sales growth, sales productivity, and profitability (Schloetzer, 2012). Empirical study also suggested that extensive *collaboration* with NLNG suppliers including operations integration using IT and automation, and internal collaboration provide greater visibility on available materials and utilisation of data to improve SCFP in NLNG systems. IT-based SCM systems increase gross margin, inventory turnover, market share, ROS, and reduce selling, general and administrative expenses (Dehning *et al.,* 2007).

Similar to study phase one, findings have established that *cost* is a key SCFP measurement criteria in NLNG networks. *Cost* is a major SCPF driver (Banomyong and Supatn, 2011). *Cost* reduction has positive impacts on financial metrics in NLNG supply chains, including profit and ROI. *Costs* in NLNG supply chains include feedgas, maintenance, production, security, personnel, taxes, levies, exchange rates, insurance, planning, logistics, procurement and finance *costs*, which have impacts on financial performance. "…*Key factors in NLNG SCF are feedgas price, assets maintenance costs, shipping costs, port charges and inventory costs"*, an expert at NLNG identified. Another respondent posited that *"sourcing and transportation of natural gas to the liquefaction plant is a major cost factor for LNG production".* SCM practices should incorporate *cost optimisation* strategies that will minimise expenditure across all the key *cost* drivers to improve SCFP in NLNG systems. Similar to *revenue, cost reduction* has a major impact on NLNG supply chains bottom line. Empirical results conformed to results from study phase one indicating that although sustainable NLNG operations is *costly*, the *cost* of non-compliance has a more propound negatives impacts on NLNG SCFP. Like any other oil and gas supply chains, passive practices can be catastrophic in NLNG systems. It is necessary for NLNG distribution networks to adhere strictly to HSSE, ISOs and other relevant safety, environment and service delivery standard to improve SCFP across all value streams (NLNG 2018b). Integrating quality assurance measures have a positive impact on both supply chain quality performance and business performance in terms of *cost and assets* (Li *et al.,* 2011). Sustainable SCM, encompassing social and environmental SCM are positively associated with financial performance measured by ROA and ROE, however, these positive effects can have a time lag (Wang and Sarkis, 2013).

Flexible SCM practice improves *cost efficiency* and SCFP in NLNG systems. A respondent affirmed that *"flexibility provides cost competitiveness to the supply chain, reduces cost of goods, materials and services"*. Flexible SCM strategies consisting of lean, agile, and lean/agile approaches improve both financial and operational performance, especially, lean/agile and lean strategy performed significantly better with respect to operating *cost* (Qi *et al.,* 2009). Findings also revealed supply chain glitches due to GTS leakage has *cost* implications in terms of repairs and maintenance, this has adverse impacts on SCFP in NLNG systems. Threats to both life and property have also resulted in high environmental, personnel, security, and maintenance and associated insurance *costs*, which erodes NLNG supply chain competitive advantage. A professional at NLNG lamented that *“security is a critical factor and has the potential to abort investments as a result of concomitant loss of production, maintenance costs and general operational costs*”. Empirical findings established that there are certain *costs* that are beyond the realm of SCM. For example, feedgas pricing mechanism is a major challenge affecting NLNG SCFP. *“Pricing mechanism for feedgas is a major factor as this item is the main direct cost. Changes in feedgas pricing model impacts financial performance. For NLNG this is a non-controllable element”,* an expert at NLNG lamented.

Assets utilisation, which measures how much profit a firm generates relative to assets employed enhances financial performance (Elgazzar *et al.,* 2012). Empirical study established that reliability of feedstock, as well as the condition of the NLNG plant affect asset reliability and utilisation. It was revealed that GTS sabotage has impacts on *asset utilisation* because it could halt production and render all assets unproductive. Results have also shown that supply chain flexibility affects *assets utilisation* in NLNG networks and financial performance. To improve SCFP in NLNG supply chains, there should be a clear assets integrity strategy, encompassing asset maintenance plans, which will improve plant reliability and availability, minimise downtime, and avoid tank tops, and resultant improvements in ROI and ROA.

Results revealed that SCFP drivers in NLNG such as sourcing strategy, *integration* and supply chain flexibility can be measured using *working capital management*, which includes payables, receivables and inventory management. Similarly, Han and Dresner (2013) revealed how inventory management enhances financial performance in terms of ROA and ROS. Empirical studies further established that SCM practices influence *working capital*, cash flows and liquidity in NLNG networks. An expert at NLNG identified that "*working capital management including advance funding to ensure timely supply of input materials as well as receivables management*" are key components of SCFP in NLNG supply chain. Another, respondent identified that NLNG SCFP "…*is influenced by the working capital need of the business and availability of surplus cash*". SCM practices have a positive impact on firm financial performance; indicating that improving SCM practices enhances return on capital employed and C2C cycle time (Johnson and Templar, 2011). Supply chain flexibility affects NLNG SCFP, *"…especially on working capital efficiency and utilisation rates",* a respondent argued. Extensive integration with suppliers including operations integration using information technology, as well sourcing strategy is also measurable using *working capital*. It is argued that *"greater partnering with suppliers including operations integration using information technology…* and *outsourcing of warehousing to reduce inventory has influences on working capital…"* and enhances NLNG SCFP. Although inventory and cycle time are useful for measuring the performance of supply chain companies (Martin and Patterson, 2009), the general improvements were marginal (Losbichler *et al.,* 2008).

Study phase three established that NLNG SCFP measuring criteria consist of all the components of EVA: *revenue growth, costs reduction, working capital efficiency* and *fixed assets utilisation* (Figures 6.1; 6.2; Appendices 17; 18). However, *cost* and *revenue* are the dominant criteria. This is consistent with study phase two findings where *revenue* and *cost* were prioritised as distance first and second SCFP measurement criteria in NLNG systems. Similarly, findings revealed that key benefits of LTC in NLNG supply chains are stability of *revenue* which attracts reduction in *cost of project finance and investment* into NLNG systems. Supply chain glitch due to GTS sabotage results in the inability of NLNG supply chains to match demand and supply which has sententious adverse effects on financial performance.

6.6 Taxonomy of SCFP in NLNG supply chain systems

Similar to supply chains analysed in study phase one, NLNG supply chain comprises of many value chains across different locations which aim to add value at every chain level to achieve financial and non-financial performance across the entire network. A case study method was adopted by this study, which focuses on value chains situated within mid-stream NLNG supply chain, from sourcing of feedgas to LNG delivery to import terminals. NLNG supply chain participants mostly interact and make decisions using communications technology. Each value chain has a mandate or strategy to make or implement decisions that have financial influences. Supply chain strategies play an increasingly important role in supply chain growth and survival, however, little is known about strategies that drive SCFP, its dynamics and effectiveness in LNG supply chains, to some extent the oil and gas industry supply chain in general. NLNG strategies are calculated, competitive, robust, *costly* and highly complex.

Using template analysis (King and Brooks, 2017; Brooks et al., 2015), study phase one developed a taxonomy for SCFP deductively by extracting explicit constructs from literature, consisting *sourcing strategy, IT and automation*, *integration and collaboration* and *sustainability* as higher-order themes. The same methodology was utilised in study phase three and established a taxonomy for NLNG SCFP inductively by conducting interviews with identified professionals at NLNG to extract latent SCFP constructs. Experts' knowledge and experiences in an unconscious or dormant form that has the potential to provide understanding of SCFP in NLNG CS systems are obtained and coded for analysis. This helps to avoid data elimination and prevent researcher bias. The taxonomy defines NLNG SCFP drivers logically, for example, *investment* includes JV financing as well as funding from other financiers such as financial institutions; and *sustainability* includes social and environmental factors, and business growth and survival. Template coding conventions (King and Brooks, 2017; Brooks et al. 2015) are retained to ensure consistency (Appendices 17; 18).

The final empirical template (Appendix 18) defines the drivers of SCFP in NLNG systems with higher-order themes and second-level themes encompassing (1) *feedgas supply*, which involves (1.1) planning and demand management, (1.2) security of gas supply, (1.3) reliability and timely supply of feedgas, (1.4) feedgas pricing mechanism, (1.5) contracting and procurement strategy, (1.6) partnering with supplies, (1.7) procurement, (1.8) outsourcing of warehousing and (1.9) limited number of feedstock suppliers. (2) *IT and automation*, consists of (2.1) integration with suppliers, (2.2) technological innovation, (2.3) relative age/condition of plant, (2.4) LNG vessels ownership and (2.4) construction complexities. (3) *Integration and collaboration*, is made up of (3.1) collaborating with supplies, (3.2) communication, (3.3) LTCs, (3.4) risk sharing, (3.5) internal integration, (3.6) mergers and acquisitions/JVs and (3.4) trustworthiness. (4) *Investment,* which contains (4.1) project economic viability, (4.2) socio-economic factors, (4.3) access and cost of project finance and (4.4) marketing strategy. (5) *Sustainable SCM*, is made up of (5.1) social dimensions, and (5.2) environmental dimensions. (6) *Capacity development*, consist of (6.1) retention of knowledge base and sustained capacity development, (6.2) organisational culture, (6.3) local content capabilities, (6.4) security issues, (6.5) employment of youth with potentials.

In conformity with study phase one (Appendix 2), the final empirical template (Appendix 18) revealed that NLNG supply chain measures SCFP using conventional accounting metrics of *revenue, cost, working capital* and *asset utilisation* (Appendix 18). (7) *Cost reduction*, includes (7.1) planning cost, (7.2) feedgas price, (7.3) security cost, (7.4) infrastructure cost, (7.5) cost of goods, materials and services, (7.6) production/liquefaction cost, (7.7) insurance premium, (7.8) assets maintenance costs, (7.9) shipping costs/port charges, (7.10) inventory costs, (7.11) procurement and logistics costs, (7.12) taxes and levies, (7.13) finance cost, (7.14) ROI, (7.15) profit and (7.16) earnings before interest and tax (EBIT). (8) *Working capital efficiency*, includes (8.1) advance funding, (8.2) receivables management, (8.3) inventory management, (8.4) provision of information and (8.5) liquidity. (9) *Asset utilisation*, is made up of (9.1) asset integrity, and (9.2) ROI. (10) *Revenue growth*, which contains (10.1) production capacity, (10.2) loss of production, (10.3) global oversupply of LNG, (10.4) ROI, (10.5) profit, (10.6) EBIT and (10.7) market share. These categories show the justification for SCFP in case the taxonomy is incomplete, empowering NLNG supply chains to identify sub-categories and develop the taxonomy.

The taxonomy for SCFP in NLNG supply chains established a theory unique to NLNG SCFP (6.5.1). In addition, the emergence of new themes in study phase three facilitated triangulation of study phases one, two, and three (Figure 6.2), as well as the modification of study phase one conceptual framework (Figure 3.2) to develop a novel conceptual framework of SCFP in NLNG systems (Figure 6.1).

6.6.1 NLNG supply chain financial performance defined

The empirical taxonomy defines SCFP in NLNG systems as *the ability to optimise feedgas supply, IT and automation, integration and collaboration, investment, sustainability and capacity development strategies across NLNG supply chains, as well as the continuous interaction between these supply chain drivers, to realise the full financial benefits of a SCM.*

6.7 Unexpected findings from qualitative analysis

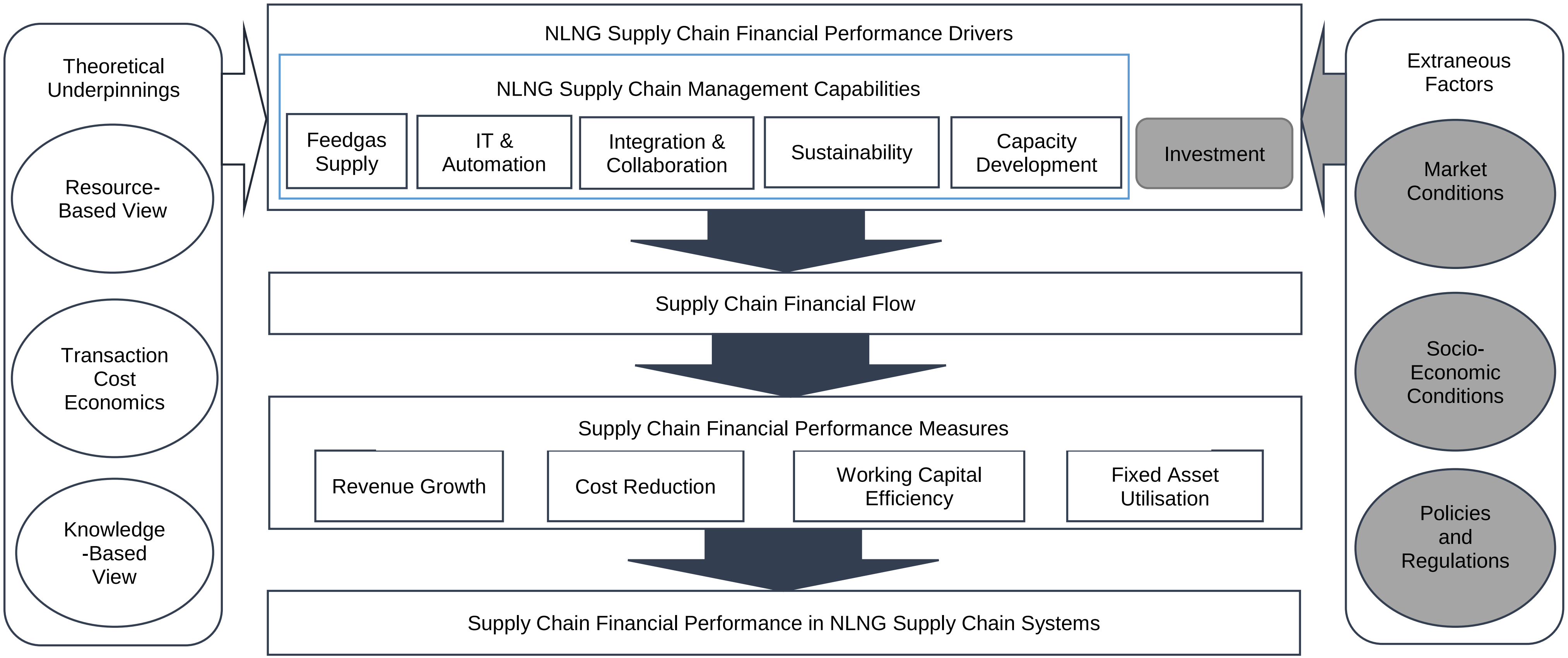
Template analysis of interviews conducted in study phase three revealed a key unexpected finding regarding the drivers of SCFP in NLNG networks. Empirical results established *Investment* as a new higher-order theme of SCFP in NLNG systems. Findings revealed that although *investment* is not regarded as one of the SCM initiatives in theory, the capital-intensive nature LNG supply chain networks, as well as the *investment challenges* facing the NLNG have made *investment* a dominant higher-order theme due of its impact on NLNG SCFP as well as on other SCM capabilities, especially *IT and automation, capacity development* and *sustainability.*

NLNG project viability, including market environment, contractual arrangements and sourcing of feedgas has a significant influence on *investment* into NLNG supply chains. In addition, socio-economic factors such as political stability, government policies and regulatory frameworks are key factors to be taken into consideration when developing an *investment* strategy to drive SCFP in NLNG distribution networks. It was established that access and cost of financing as well as marketing strategy also impact *investment* decisions in NLNG systems.

6.8 Confirmation and validation of study phase three findings

To minimise error and enhance the quality of this study, a summary of study phase three findings was shared with strategic decision-makers at NLNG for validation. NLNG supply chain professionals upheld that the findings are applicable and will make important contribution to SCFP in NLNG systems. However, experts at NLNG made a recommendation that the higher-order themes that emerged in study phase three, *investment* and *capacity development* should be defined within the context of NLNG supply chain in this study for better understanding of the discussions that follows. Industry recommendation was considered and implemented accordingly in this research. An improved copy of the executive summary was shared with experts at NLNG, which they considered significant to SCFP in NLNG systems (Appendix 19). In addition, study phase three findings were presented to practitioners at the LNG Bunkering Conference for further validation. Industry leaders endorsed all the strategic findings (Figure 6.1)

Figure 6.1: Proposed framework for optimising supply chain financial performance in NLNG supply chain systems



Source: Author

6.9 Triangulation of findings

Multiple data sources including publications, surveys and interviews relevant to SCFP in NLNG were utilised to address the research question: *how can operators in NLNG systems improve SCFP?* Triangulation is used in logistics and SCM case studies to explore theory, validate models, refine and extend theory using multiple evidences to review theory through multiple comparisons (Dinwoodie and Xu, 2008). Empirical findings from both qualitative and quantitative data enables triangulation to synthesize the similarities between the findings of study phases one and two, as well as the distinctive findings synonymous to NLNG systems established in study phase three (Figures 3.2; 5.4; 6.1; 6.2; Appendices 2; 18).

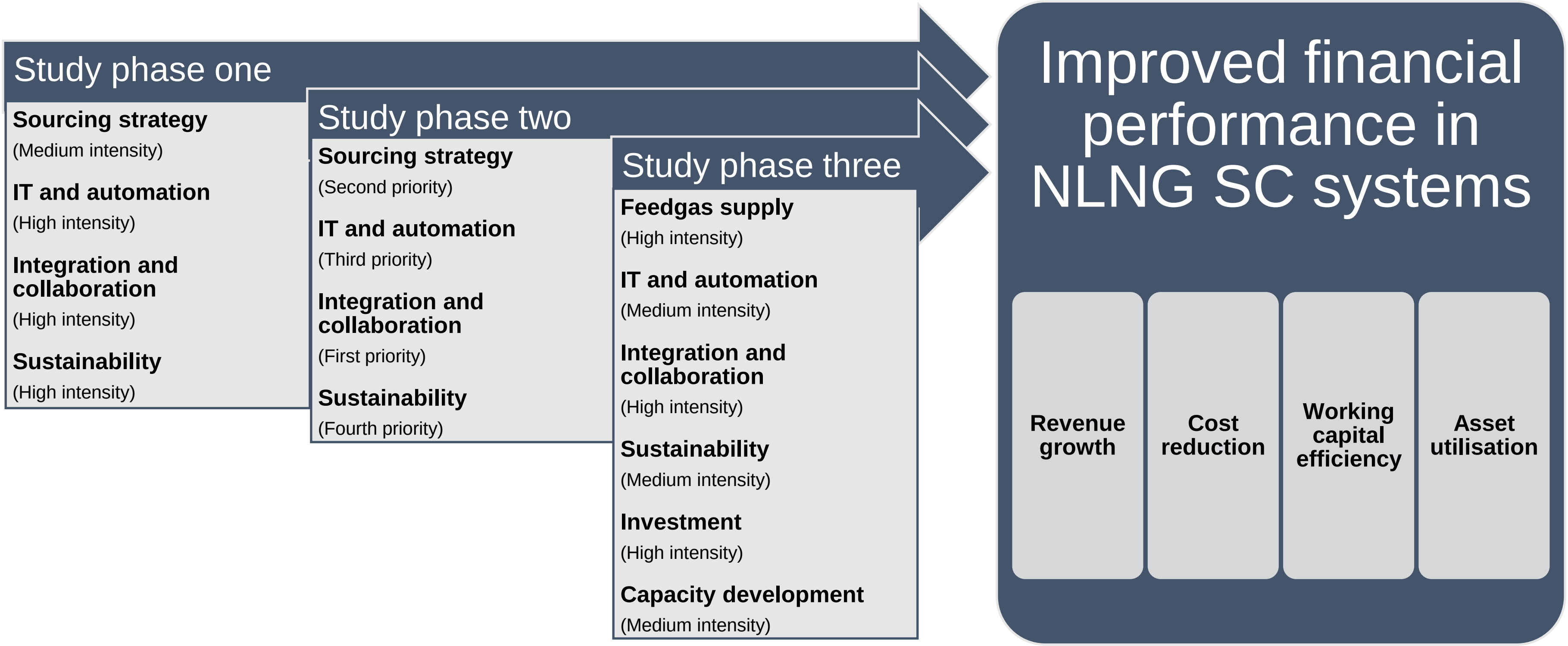
In study phase one, SCFP systematic literature findings established *sourcing strategy, IT and automation, integration and collaboration, and sustainability* as the generic SCM capabilities/initiatives that drive SCFP. Study phase one further established that *integration and collaboration* is the most dominant SCFP driver followed by *IT and automation*. However, to fully optimise financial performance all the four initiatives should be employed across a supply chain, as none of the supply chain capabilities is a standalone driver of SCFP. Study phase one also identified *revenue growth, cost reduction, working capital efficiency* and *assets utilisation* as generic SCFP measures.

Quantitative AHP method measured the relationships and prioritised the generic variables of SCFP in NLNG setting in study phase two. AHP results corroborated study phase one findings that *revenue growth, cost reduction, working capital efficiency* and *assets utilisation* are key SCFP measuring criteria and were ranked first, second, fourth and third respectively. Amongst the established SCFP drivers, AHP results prioritised *integration and collaboration* and *sustainability* as first and fourth, which are similar to study phase one findings due to their relative dominance in study phase one. However, AHP findings ranked *sourcing strategy as second, ahead of IT and automation* which is relatively more dominant in study phase one due to its impacts on *integration and collaboration*. Further analysis established that the strong priority given to *sourcing strategy* in NLNG systems was because of the security challenges facing NLNG GTSs as source of feedstock. Study phase two only measured relationships, but does not identify any new SCFP driver/capability.

Study phase three applied a qualitative method to assist in achieving a closer relationship with the case study, which allowed for discovery of latent factors that might not have been taken into consideration. All the four SCFP drivers established in study phase one resurfaced, with modification of *sourcing strategy* to *feedgas supply*, which is due to industry terminology and the essence of feedgas as the key feedstock in NLNG systems. However, two key drivers emerged in study phase three, viz., *investment* and *capacity utilisation*. On one hand, SCM theories do not categorise *investment* as a SCM capability, however, due to the capital intensive and vertically integrated nature of NLNG supply chain, *investment* drives financial performance and has two-way relationships with other supply chain capabilities in NLNG supply chains. On the other hand, SCM theories categorised *capacity development* as a SCM initiative, however, *capacity development* only appears as a sub-theme in study phase one. *Capacity development* emerged as a higher-order theme for SCFP in NLNG in the final empirical template (Table 6.2; Figure 6.1; Appendix 18) owing to the necessary skills required to operate in such specialist and sophisticated automated supply chain systems. A theoretical framework may explain some findings but not all, giving room for theory development from findings (Corbin and Strauss, 2008). A taxonomy of SCFP in NLNG networks embrace and combine all the six higher-order themes and developed an empirical framework of SCFP. If the researcher wants to develop a theory, a previously identified theoretical framework can offer insight, guidance and useful list of concepts. However, the researcher should remain open to new ideas and be willing to let go if it is discovered that certain concepts do not fit the data (Corbin and Strauss, 2008), hence this study come up with a modification to existing theories.

Triangulation facilitated the deployment of more than one method of investigation, and safeguards validity and reliability of findings (Creswell and Poth, 2018:328; Saunders *et al.,* 2016). Triangulation provides greater confidence that if propositions that emerged from findings are apprehended and implemented, this will result in holistic financial benefits for NLNG systems.

Figure 6.2: Combining SCM capabilities to improve financial performance in NLNG supply chain systems



Source: Author

6.10 Summary of chapter six

This chapter developed a taxonomy that defines SCFP in NLNG systems by interviews undertaken with professionals at NLNG. Interviews were analysed using template analysis to capture tacit expert knowledge, experience and understanding of SCFP capabilities in NLNG systems. Akin to study phase one, a taxonomy of SCFP in NLNG systems includes *revenue growth, cost reduction, working capital efficiency* and *assets utilisation* as key SCFP measures in NLNG networks. Similarly, consistent with study phase two; *cost* and *revenue* are the dominant criteria.

The taxonomy for SCFP in NLNG systems comprises of *investment* and *capacity development* in addition to the supply chain strategies established in study phase one: *sourcing strategy, integration and collaboration, IT and automation*, and *sustainability* as SCFP drivers in NLNG systems. Although study phase one does not classify *investment* as a SCM capability, *investment* emerged from template analysis of interview data as a key driver of financial performance in NLNG logistics systems, largely due to the capital intensive nature of the industry and country's peculiarities, specific to NLNG networks. The taxonomy suggests that effective implementation of these initiatives is essential to realise the full financial advantages of effective supply chain strategies in NLNG systems. Next chapter discuss key findings and conclusions for the study.

Chapter seven: Discussion and conclusions

7.1 Chapter seven overview

The impact of SCM strategies on NLNG systems has been extensively examined in this study. This chapter discusses the overall findings followed by their implications along with recommendations for future work. This chapter begins by addressing the prime research question, considering each of the six research objectives by reviewing the research processes which have been undertaken to achieve these objectives and discussing the findings in relation to each objective. The reminder of the chapter presents the contribution of the research to theory, policy and industry, followed by consideration of the limitations of the study upon which directions for further research are suggested.

7.2 Realisation of the research objectives

The prime research question that this thesis addresses is: *how can operators in NLNG systems improve SCFP?* To address the research question, this study addressed all six objectives set out in Chapter one. This section presents how each of the six objectives was achieved individually, and when taken together collectively, they address the prime research question. These objectives are arranged sequentially, and achievement of each objective serves as a springboard for the subsequent objective.

7.2.1 Objective one: To identify the characteristics of LNG systems

To achieve this objective, relevant SCM literature, including definitions and changes in systems were reviewed in Chapter two. Further, LNG SCM related publications were reviewed and analysed to identify the characteristics of LNG systems. These issues were explored in relation to NLNG as a case study. Analysis revealed that similar to extant SCM literature findings, *NLNG systems consist of a series of networks across different locations, which add value at every chain level from source to delivery of LNG to consumers.* These networks consist of upstream, which include natural gas extraction, feedgas supply; midstream, which consist of gas treatment, liquefaction, storage, and shipping; and downstream, which comprise of regasification and distribution. *NLNG has mainly control of the midstream supply chains.*

The NLNG supply chain begins with the extraction of natural gas from various concession areas in both the onshore and offshore fields of Niger Delta by three JV partners under a long-term Agreement with each JV. The feedgas is supplied via six dedicated gas transmission pipelines to NLNG complex at Bonny Island. The gas is treated to remove other materials and particles, then processed by production trains through a refrigeration process into a liquid state, and stored in tanks. Currently, there are six trains with capacity of producing 22 Mtpa. Plans for building Train 7 that will increase the total production capacity to 30 Mtpa awaits FID by the shareholders. The next stage is LNG shipment to its destination terminals using specially designed vessels. NLNG has a total of 23 LNG vessels on long-term time charter dedicated for its LTC under DES, 13 of these vessels are owned by BGT, an NLNG wholly owned subsidiary, and 10 by third party companies. To support spot short-term cargo deliveries, additional third party ships are chartered on an ad-hoc basis under FOB. Delivery at import terminal marks the end of NLNG participation in the supply chain. LNG is handed over to buyers upon delivery, it is again stored until it is regasified and finally sent through pipelines to the end users (Figure 2.5). *The characteristics of LNG supply chains* *can be described as a set of value chains consisting of exploration and production, liquefaction, shipping, regasification and distribution.*

A limited number of studies have been conducted that identified the characteristics of LNG supply chains and this is the first study that identifies these characteristics in an NLNG supply chain context. Achieving this objective provides an understanding of the NLNG value chains and their characteristics, and the position and functions of NLNG within the supply chain systems.

7.2.2 Objective two: To analyse the objectives of SCM in LNG distribution systems

In Chapter two, LNG SCM related literature and industry publications are reviewed to analyse the objectives of SCM in LNG distribution systems. Findings revealed that the first value chain in NLNG distribution systems is feedgas supply via GTS from remote locations to a liquefaction facility at Bonny. *The objective of feedgas supply is steady usage without any interruptions*, and it is currently the only method of transporting the feedstock required for operations. However, the security of NLNG gas supply systems remains a critical challenge, with a number of threats to gas supply reliability, including GTS leaks due to third party sabotages. These incidents resulted in force majeure declarations by two of the three feedgas suppliers in 2015, which undermined the objective of feedgas supply during that period.

Another key and most capital-intensive value stream is liquefaction of feedstock to LNG using the existing six LNG trains. *The goal of a liquefaction plant is to maximise utilisation without interruption*. NLNG has almost achieved this objective because as at the end of 2017. NLNG achieved 92% capacity utilisation in its LNG trains, and only Qatar performed better amongst the top five LNG exporters. However, the key challenge remains that NLNG has a limited capacity of only 22 Mtpa, which makes NLNG fourth out of five major LNG exporters. NLNG is the only major LNG exporter not to invest in liquefaction capacity for over a decade since the launch of NLNG Train 6 in 2008.

The shipping network consisting of owned and chartered vessels is a major driver of financial performance in NLNG distribution systems. To maximise profits, *the objective of the shipping network is that it should never require the LNG liquefaction plant to reduce production and to minimise cost of investment in LNG fleet and associated OPEX.* NLNG supply chain participants have channelled a significant portion of their *investment* into vessel capacity. Nigeria LNG has disposed of six of its aging and smaller vessels in 2015 and replaced them with six newer and larger capacity vessels between 2015 and 2016. A total of 13 owned and 10 chartered vessels support reliable delivery of NLNG cargo to its customers around the world. Analysis revealed that the NLNG distribution network has adequate vessel capacity relative to current production levels.

The objective of SCM in NLNG is to satisfy customers in an economically efficient manner to maximise investors' wealth. Only Berle *et al*. (2013; 2011) had previously conducted an empirical analysis of generic LNG transportation systems. This study analysed the objectives of SCM in NLNG distribution systems. Objectives one and two provide a comprehensive framework for SCM in NLNG systems, however, the industry literature review failed to establish an explicit construct of SCFP in NLNG systems.

7.2.3 Objective three: To synthesise strategic drivers, capabilities and measures of SCFP

To synthesise strategic drivers, capabilities and measures of SCFP, this study systematically reviewed SCFP related publications covering 20 years, between 1999 and 2018, to analyse how SCM capabilities that drive financial performance evolved and to propose an updated generic taxonomy of SCFP in study phase one (Chapter three). Template analysis of the data set identified *sourcing strategy, information technology and automation, integration and collaborations* and *sustainability* as critical supply chain initiatives that drive financial results. Further, SCFP measures include *assets utilisation, working capital, revenue* and *cost.* An optimal level of *integration and collaboration* is essential to realise the full financial advantages of effective SCM (Figure 3.2; Appendix 2).

The taxonomy makes a significant conceptual contribution, which assists understanding of how SCM practices contribute positively to industry and corporate financial performance, and supports practitioners in making strategic supply chain decisions. Recent and extended literature incorporates *sustainability* and automation as SCFP drivers, and measures include all the four components of EVA: *revenue growth, cost efficiency, working capital efficiency* and *fixed asset utilisation*.

This synthesis of strategic drivers, capabilities and measures of SCFP was developed from multifarious SCF related studies using different research approaches and methods, conducted across diverse industries of different sizes and across different locations. However, this theoretical construct has been presented to decision-makers at NLNG for validation and confirmed that the conceptual framework is applicable to SCFP in NLNG systems.

7.2.4 Objective four: To assess the SCFP capabilities in NLNG systems

Study phase two (Chapter five) findings prioritised the SCFP drivers and measures established in study phase one in NLNG systems using quantitative survey data collected from experts at NLNG. The prioritisation was conducted using AHP to measure the relative weight of each of the identified SCFP drivers on NLNG SCFP. *Analysis of group decision-making reveals revenue growth and cost reduction as the first and second most important factors for consideration when measuring SCFP in NLNG systems respectively.* Cumulatively, *revenue growth* and *cost reduction* represents over 62% of the SCFP measuring criteria in NLNG systems. *The third ranked criterion for measuring SCFP in NLNG is fixed assets utilisation*, which increased the accumulated weight to 82%. *Working capital efficiency was ranked as the fourth and considered as the least important SCFP measurement criterion by experts* (Table 5.2; Figure 5.3).

Aggregate NLNG group analysis identified integration and collaboration as the most important driver of financial performance in NLNG supply chain, followed by strategic sourcing, and IT and automation. Findings present sustainability as the least ranking driver of SCFP in NLNG systems (Table 5.3; Figure 5.4). *These results suggest that optimal levels of integration and strategic feedgas sourcing initiatives are essential to realise the full financial advantages of effective supply chain strategies in NLNG systems*. However, collective analysis for key divisions at NLNG as sub-groups reveal different variation in priorities, which could be attributed to the nature, roles, challenges and objectives of each division. Analysis of the collective response from experts in the MD and Production divisions regarding SCFP drivers in NLNG prioritised sourcing strategy, *integration and collaboration*, *sustainability*, and *IT and automation* as first, second, third and fourth respectively. Findings from the Finance division ranked sourcing strategy, *integration and collaboration*, *IT and automation* and *sustainability*, as first, second, third and fourth, while analysis of the Shipping division ranked *integration and collaboration*, *IT and automation*, *sustainability*, and sourcing strategy, as first, second, third and fourth respectively (Table 5.5).

Further assessment revealed key factors that influence SCFP capabilities in NLNG systems. For example, both NLNG *supply chain integration and sourcing strategies* are significantly influenced by *cost effectiveness* and reliability of delivery. *Sustainability* strategy in NLNG systems is driven by economic benefits, health and safety agenda, compliance with ISO 14001, brand reputation and other environmental and social considerations.

7.2.5 Objective five: To develop a taxonomy that defines SCFP in NLNG systems

To develop a taxonomy that defines SCFP in NLNG systems, interviews undertaken with professionals at NLNG were analysed using template analysis in Study phase three, to access tacit expert knowledge, experience and understanding of SCFP capabilities in NLNG systems*. In conformity to study phase one, a taxonomy of SCFP in NLNG systems includes revenue growth, cost reduction, working capital efficiency and assets utilisation as key SCFP measures in NLNG systems* (Figures 6.1; 6.2). In addition, *consistent with study phase two, cost and revenue are the dominant criteria*. The taxonomy for SCFP in NLNG systems indicates that *revenue growth* enhances ROI and shareholders wealth. High *revenue* associated with spot sales enhances financial performance in NLNG networks, however, uninterrupted *revenue* streams associated with LTC provide more sustainable financial gains to NLNG supply chains. Further, GTS vandalism causes a supply chain glitch, which results in loss of potential *revenue*. The taxonomy indicates that *cost reduction* has positive influence on financial metrics in NLNG supply chains, including profit and ROI. *Costs* in NLNG systems include feedgas, maintenance, production, security, personnel, taxes, levies, exchange rates, insurance, planning, logistics, procurement and finance *costs*, which have influences for financial performance. Reliability of feedstock and the condition of the NLNG plant affect the rate of *assets utilisation*, which has influence on ROI and ROA. The taxonomy revealed that SCF practices influence *working capital*, cash flows and liquidity in NLNG networks.

The taxonomy for SCFP in NLNG systems consists of investment and capacity development in addition to the supply chain capabilities established in study phase one, *including sourcing strategy (feedgas supply), integration and collaboration, IT and automation, and sustainability as SCFP drivers in NLNG systems.* Although extant literature does not categorise *investment* as a SCM capability in study phase one, *investment* emerged from template analysis of empirical data set as a key driver of financial performance in NLNG distribution networks, largely due to the capital-intensive nature of the industry and country's peculiarities, specific to NLNG systems. The taxonomy suggests that effective implementation of these initiatives is essential to realise the full financial advantages of effective supply chain strategies in NLNG systems.

7.2.6 Objective six: To propose strategies and policies to improve SCFP in NLNG systems

Findings from studies phase one, two and three enabled this research to achieve its ultimate objective, to propose strategies and policies to improve SCFP in

NLNG systems. *In study phase one, template analysis of candidate publications between 1999 and 2018 propose sourcing strategy, IT and automation, integration and collaborations and sustainability as critical supply chain initiatives that drive financial results*. These are presented as propositions one, two, three and four (Sections 3.5.1 - 3.5.4). However, study phase one propositions are generic in nature rather than NLNG specific propositions because the strategies emerged from a variety of SCM related studies conducted across diverse industries of different sizes and across different locations.

Study phase one findings are validated by experts at NLNG and subsequently assessed in NLNG systems using AHP. *AHP prioritised integration and collaboration, sourcing strategy, IT and automation and sustainability as first, second, third and fourth strategies that drive financial performance in NLNG systems.* These strategies are recommended as propositions five, six, seven and eight (Sections 5.8.1 - 5.8.4). Further, template analysis of empirical interviews conducted at NLNG validates these propositions and established two additional propositions specific to NLNG systems, *investment* and *capacity development,* which are necessary to enhance financial performance across NLNG networks (Sections 6.3.1 - 6.3.6).

This study proposes that to maximise supply chain *integration and collaboration* strategy and enhance financial performance in NLNG systems, strategy should incorporate mutual trust, cooperation and commitment plans, as well as deployment of relevant integrative IT infrastructure. The LNG market is changing rapidly, due to a growing spot market, changing contractual terms and demand uncertainties. In this regard, NLNG may consider a *collaborative shipping* strategy that will allow for split deliveries of cargoes to *reduce shipping costs* and increase *revenues.* In addition, NLNG should continue to *collaborate with its long-term customers* to explore alternative commercial initiatives such as diverting of more LNG cargos to high value markets strategically. Supply chain *integration and collaboration* strategy should incorporate clear plans for market expansion (Sections 5.8.1; 6.3.3).

It is established that threat to *feedgas supply* can lead to shutdown of the entire NLNG networks, and AHP results suggest that *feedgas supply strategy* as the second most important driver of SCFP in NLNG systems has to be assiduously assessed and planned. To improve financial performance in NLNG systems, *feedgas strategy* should consider the possibility of burying pipelines deeper, in addition to incorporating necessary security measures to mitigate against third party sabotage. In addition, NLNG supply chain participants should explore the possibility of investing in offshore liquefaction platform, which will mitigate against pipeline vandalism and boost liquefaction capacity and financial performance. The Nigerian government should provide an enabling environment for LNG investors by improving local infrastructure and addressing socio-political unrest (Sections 5.8.2; 6.3.1).

This research recommends that IT and automation strategy is vital to NLNG systems, and that *investment* in *automation* would significantly increase the global competitiveness of NLNG which will result in gestalt financial benefits to its supply chains. Automation strategy should be developed to ensure that NLNG train 7 projects come to fruition. *IT and automation strategy* should consider the possibility of setting up an offshore liquefaction project to improve capacity and mitigate against security challenges such as pipeline vandalism. *IT and automation strategy* is more effective when backed by requisite *investment and* *technical skills*, and when there is *collaboration and integration* with NLNG systems. However, due to the capital-intensive nature of LNG automation, *strategic decisions should be made based on the technology configuration that maximises NPV generated by NLNG supply chains for each technology option, and at any given LNG throughput requirement*. (Sections 5.8.3; 6.3.2).

This study proposes an optimal sustainability strategy for NLNG networks, which presupposes that environmental action and social development should be given the same importance as economic gains. NLNG supply chain participants should develop a holistic framework to incorporate *sustainability* within the supply chain strategy. Corporate decision-making should ensure that *sustainable development agenda* is integrated and maintained throughout NLNG supply chains. Strategic decision-making regarding *sustainability* should be carried out in consultation with the host communities and in line relevant local and international regulatory frameworks. This approach will help to reduce tension between host communities and NLNG supply chains (Sections 5.8.4; 6.3.5).

This study suggests that although investment is not regarded as one of the key SCM capabilities in theory, investment strategy is a major driver of SCFP in NLNG distribution systems. NLNG project viability, including market conditions, contracts and access to feedstock is a determinant for *investment* into NLNG supply chains. Socio-economic factors such as political stability, and policies and regulatory requirements should be considered when developing an *investment strategy* to drive financial performance in NLNG logistics systems. NLNG supply chain *investment strategy* should consider access and *cost* of financing as well as marketing strategy.

This research proposes that levels of investment, technology implementation, integration intensity, environmental conditions and availability of skilled labour facilitate capacity development as a SCFP strategy in NLNG systems. NLNG networks consist of complex and risky operations, which require some level of expertise to operate safely and efficiently to improve financial performance across NLNG systems. *Capacity development and retention* facilitates internal integration as well as external integration with suppliers and customers, which enhances flow of information, material and finance within and across NLNG supply chain systems. *Capacity development strategy should make provision for appropriate recruitment and training policies and funding to enhance SCFP in NLNG systems* (Section 6.3.6).

To fully optimise financial performance, all the six initiatives (collaboration and integration, sourcing strategy, IT and automation, investment, sustainability and capacity development) should be employed across NLNG systems, as none of the supply chain initiatives is an independent driver of financial performance.

7.3 Implications of the study

SCM has significant influences on NLNG networks performance, including financial performance. *This study proposes an explicit taxonomy of SCFP in NLNG systems, and strategies and policies to guide NLNG supply chain participants to improve financial results*. Rigorous three-phased empirical research undertaken using mixed methods of data collection and analysis facilitated triangulation, and findings suggest that effective SCF outcomes in NLNG networks are a function of appropriate supply chain initiatives. The key implications of this study are described separately as implications for research, policy and practice.

7.3.1 Implications for knowledge/literature

The study established that to date there is only one prior statement (Shi and Yu, 2013), which explicitly presented a combination of SCM competencies that drive financial performance, which consist of *sourcing strategy, technology, system integration and external relationships*, measured by *revenue, cost and working capital*. All other qualifying articles study the relationship between supply chain strategy and financial performance using disjointed drivers such as integration and information sharing or human resources or technology. Other publications (Cristopher, 1998; Christopher and Ryals, 1999), presented only the supply chain measuring criteria without showing combinations of the supply chain capabilities that drive financial performance. This study extends existing literature by identifying updated drivers and sub-drivers that enhance financial results. The final template for SCFP introduced new themes and modified a majority of the existing themes to develop an updated definition of the construct of SCFP. *Sourcing strategy* and *information technology* remain much as in the base definition, but *integration and collaboration* combine both *system integration* and *external relationships*. *Sustainability* is a new higher-order theme which develops as further data emerges to devise an updated explicit taxonomy of SCFP.

This research also enhances literature by establishing two additional key drivers, viz., *investment* and *capacity utilisation* as key themes explicit to SCFP in NLNG systems. Findings denote that although all the generic SCFP drivers are applicable to NLNG networks, and there are additional drivers synonymous with certain supply chains; meaning that SCM strategies are not one-size-fit-all variables, rather they are industry, period or location specific capabilities. This facilitates theory building by defining SCFP in LNG systems, a phenomenon that has never been defined before this study.

Only a couple of prior studies (Elgazzar, 2013; Elgazzar *et al.,* 2012), established the relative importance weights of supply chain performance measures with respect to the priorities of financial performance. This study is the first to further extend prior literature by establishing the relative importance of both SCM initiatives and measures to guide practitioners and researchers on how to design and prioritise supply chain strategies to improve financial results.

The study reveals two methodologies that were applied to achieve varied objectives that ranged from the hypothetical to empirical applications of an SCFP framework. Template analysis successfully captured the high variation of outcomes often reported and identified common and shared themes. Template analysis enabled the identification of generic supply chain initiatives, tested the identified strategies in an industrial context and explored non-specific supply chain initiatives, including rarely reported themes, in a given sector. These factors have important influences for financial performance, and require key strategic decisions and implementation.

Template analysis facilitates the development of a taxonomy of SCFP in NLNG systems and established a unique theory that defines SCFP in an industrial context. In addition, emergence of new themes in study phase three facilitated triangulation and modification of theories and frameworks to develop an original conceptual framework for SCFP in NLNG supply chains.

AHP as an MCDM technique is important in measuring the relative weight of various SCM strategies to prioritise their financial influences in a given supply chain network. AHP ranks SCM initiatives according to their impact on business survival and growth and value creation for investors. In addition, the empirical framework revealed three established theories that underpins SCFP in NLNG systems, viz., TCE and RBV which are strongly associated with *integration and collaboration*, *sourcing, IT and automation* strategies as dominant SCFP drivers, and KBV which is synonymous to *capacity development* and *sustainability*.

This study contributes to SCF literature by exploring a phenomenon based on clearly defined theoretical and methodological foundations and identifies how supply chain competitive initiatives drive financial performance to guide network participants. Findings underline the need to incorporate SCM initiatives as part of corporate strategy to improve financial results across supply chain systems. In addition, the proposed strategies for improvement are grounded in experts' knowledge, which can be replicated.

7.3.2 Implications for policy

This study highlights the significant influences of LNG supply chain activities to environment, societies and economies. *NLNG supply chain operations contributes significantly to Nigeria's economy in terms of national income, taxes, employment and various CSR related activities*. Improvements in NLNG SCFP will have ripple effects on stakeholders, including regulators, employees, host community, general public and investors.

This research established *that attracting quality investment is a key factor in enhancing NLNG SCFP because of its impact on financial performance and other SCM initiatives*, especially *IT and automation*, *capacity development* and *sustainability*. Policies and regulatory requirements influence *investment* as a driver of SCFP in NLNG systems. Policies such as meeting domestic gas demand before exports affects NLNG SCFP especially in periods of high prices and demand globally. The desire to meet domestic gas demand also affects the ability of NLNG to secure profitable LTC and improves its SCFP. Fiscal regimes such as taxes, levies and subsidies are also key economic factors that influence *investment* in NLNG supply chains. Investors are sceptical about possible changes to the current pioneer tax incentives when the long awaited all-encompassing PIB that is broken down into smaller bills such as the PIGB and PIFB. In addition, delays in clearing of goods affects *investment* in NLNG supply chains. Stability of polices, including making amendments to the Nigeria LNG Act which confer pioneer status on NLNG and exempt the company from certain taxes, custom duties to provide for the guarantees and assurances by the Federal Government to the Company and its shareholders are significant in improving SCFP in NLNG systems.

The study reveals that another major *concern for investors* in NLNG supply chains is project economic viability, which is influenced by extraneous factors, including market volatility, socio-economic factors and regulations. Low gas prices and growing market competition continue to place pressure on the development of new projects in Nigeria. The security situation in the Niger Delta region causes social menaces and economic losses, which have an extensive impact on NLNG SCFP. The security challenge has stalled *investment* not only in the country's LNG industry but also in the entire nation's petroleum sector. Strategic efforts to address security issues by relevant stakeholders will improve *investment* and financial performance in NLNG systems.

This study established that sustainable NLNG supply chain is a component of a taxonomy for financial performance. Social and environmental *sustainable* supply chain practices have positive effects on the economic dimension of *sustainable network*, which is strongly linked to financial performance. Regulations enable effective LNG supply chain *sustainability*, because *sustainable strategy* is more efficient when implemented jointly by all supply chain participants. This research further reveals regulatory guidelines and requirements, which are designed to assure the safe operation of onshore and offshore LNG facilities, personnel and vessels. Compliance with regulations, codes and standards such as the ISOs, enhance safety and financial performance in NLNG systems. Adhering to best practices through not-for-profit trade organisations strengthens the safety philosophy of NLNG networks. Improving SCFP in NLNG systems requires continuous commitment by regulatory authorities to reduce the risk of adverse environmental consequences, damage to equipment, facilities or vessels, and most importantly human health and wellbeing.

The increasing global demand for low sulphur energy has led to the rapid transition of LNG as energy source. There is a pressing need for a shift from the traditional business model to a more contemporary and sustainable model that reflects the challenges in the oil and gas sector, including climate change, fall in the price of petroleum products, investment infrastructure and competition. Further, a sustainable regulatory framework is key for NLNG supply chain participants and their financial performance.

7.3.3 Implications for practice

A link between SCM strategies and NLNG network financial performance emerged, grounded in an extensive review of explicit literature and rigorous *empirical research, offering an understanding of how SCM initiatives make positive contributions to financial performance in NLNG systems*. To fully optimise financial performance, the study suggests that all the six SCF initiatives, namely, *integration and collaboration, sourcing strategy, IT and automation, investment, sustainability* and *capacity development*, should be implemented across NLNG systems, as none of the supply chain initiatives is an independent driver of financial performance. Supply chain measurement criteria included four established financial measures, namely, *revenue, cost, working capital* and *fixed assets utilisation*, are established as appropriate measures for SCM strategy in NLNG networks.

This study contributes to industry by creating an original construct linking SCM initiatives to networks performance and a company's strategic financial objectives. This framework can be used as a strategic performance management tool in the design and implementation of effective SCM initiatives to enhance financial performance necessary for NLNG survival and growth. The study offers a framework for NLNG networks to gain SCM advantages. The methodology assists practical identification and application of supply chain strategies, which if prioritised and safeguarded will result in gestalt financial benefits to NLNG supply chain participants.

The study establishes a model for SCFP that prioritises SCM strategies, which can be applied by NLNG systems in the design and implementation of SCM initiatives necessary for sustainable business growth and value creation. Applying this model enables LNG supply chain participants to formulate the appropriate SCM practices based on their relative influences on financial performance. The model indicates the contribution of each SCM strategy to LNG network financial performance criteria. The model highlights factors that need more priority based on contribution to overall financial performance.

As reviewed in Chapter two, all the major LNG exporting networks shared a similar future in terms of the characteristics and objectives of their supply chain systems, participants, level of integration, contracts and *investment* requirements. *These similarities make the taxonomy, framework and model of NLNG supply chain financial performance applicable in other competing LNG systems* such as Qatar, Malaysia, Indonesia, Australia and the US to some extent. However, some variations may be required due to differences in geography and socio-economic set-up.

Careful implementation of SCM initiatives proposed by this study is central for efficient and effective logistics flows, which will ensure access to sustainable, affordable, profitable, and reliable delivery of LNG as an energy source from Nigeria to the international market.

7.4 Limitations and directions for future research

While this study has provided a valuable contribution for theory, policy and practice as discussed in the previous section, there are some limitations regarding the scope and application of some of the propositions made by this research, beyond a Nigerian case study. It envisaged that the collective empirical findings presented will provoke a much-needed discussion relating to the impact of SCM strategies on financial performance for LNG and related energy systems. As such, this study proposes a number of under-explored issues that could be addressed in future research.

The research procedure was applied to mid-stream NLNG networks, consisting of feedgas supply, liquefaction, storage and shipment, to draw a valid conclusion. The robustness of the empirical findings should be tested under different value streams. *Future research should consider studying SCM strategies that drive financial performance in the upstream and downstream of NLNG systems*. This will further validate key findings from this study and establish other supply chain strategies that improve upstream or downstream financial results that may lead to gestalt sustainable growth for the whole NLNG systems.

Due to the sensitivity of the industry, access to the case study was only granted for a specific period to enable this study to gather valuable data to achieve its objectives satisfactorily. However, the LNG industry is the fastest growing energy industry, evolving continuously. *It is important to conduct similar studies at regular intervals (for example every three years) to apprehend the changes in the supply chain operational and financial systems and establish an improve taxonomy, framework and model of SCFP in NLNG systems.* Regular periodic studies will also guide policies to suit the emerging socio-economic changes nationally and globally. This will enable NLNG to maintain a competitive position at all times that is necessary for survival and sustainable growth in a rapidly changing and risky market place.

Although, findings from this study emerge from rigorous empirical research across three phases, the initial framework was developed from diverse SCF related studies using different research approaches and methods, conducted across various industries of different sizes and across different locations. *As NLNG is growing to be the second major source of global energy supply, more studies will emerge that will enable future NLNG SCF studies to carry out* *systematic literature reviews explicit to LNG SCF.* This will enable future studies to propose improve conceptual frameworks of SCFP in LNG networks.

Practical implementation of the research procedure on the case study was not feasible over the time scale of this study; to maximise impact, it is desirable that an application of the framework is conducted in NLNG systems. *Future research with access to NLNG operations should consider collecting operational and financial data to investigate the impact of implementing the proposed supply chain strategies on improving SCFP in NLNG systems, which will facilitate informed decision-making.*

Findings are grounded on clearly defined theoretical and methodological foundations, including quantitative and qualitative methods, which enable triangulation of the three phases to propose a theoretical framework for SCFP in NLNG systems. *Future study should consider using a different combination of methods of data collection and analysis.* Qualitative researchers that can gain extended access to practical LNG supply chains should consider research strategies such as action research or ethnography to immerse themselves with latent data relevant to SCFP in LNG systems. AHP was used for this SCM strategy study that was conducted through the lens of strategic decision makers. Quantitative researchers may consider a more holistic approach where a study will be conducted from a distance to cover the entire networks using instruments such as surveys, which can be analysed using other quantitative methods. *Applications of different methods will propose and measure SCFP strategies in NLNG systems differently and add to the debate in this exciting subject in a growing industry.*

In study phase one, results imply that all approaches to SCF strive for competitive business survival and growth assessed using traditional financial performance measures, because all intangibles, environmental and social factors incur associated financial benefits and *costs* influences for supply chains. However, diverse debate obfuscates a uniform approach, and confuses practitioners seeking appropriate financial performance measures to evaluate supply chain strategy. *Creative studies are needed to design more direct measures and develop balanced systems for assessing the financial performance of the whole supply chain as well as each supply chain participant.* However, caution should be taken when developing such a comprehensive system to avoid potential conflicts between different performance measures and various stakeholders.

There are some limitations regarding the application of the construct of SCFP in NLNG systems to other similar LNG exporting networks due to differences in local policies, fiscal regimes, state of the economies and geography. Current literature has revealed that cultural and social aspects of different countries or regions have influences for SCM strategies. *Researchers with access to other LNG exporting countries can collect relevant data that capture practitioners' tacit knowledge, reality, and values to verify whether these SCM initiatives and financial measures are applicable under different environments, or if otherwise, to identify other appropriate SCPF drivers and measures.* The study provides a standard procedure based on established SCM strategies and financial performance metrics. Thus, the research procedure is generalizable and can be repeated in any of the major LNG exporting networks and other emerging energy sources including fuel cells, hydrogen and lithium-air batteries supply chains.

As the role of digital technology is increasing in the energy sector, it is of paramount importance that future studies consider the influences of technologies such as big data, blockchain, and artificial intelligent on SCFP in NLNG systems.

7.5 Summary of chapter seven

This study featured a critical supply chain in the energy sector, focusing on how to harness SCM strategies to improve financial performance. The study makes an original contribution linking SCM practices to SCFP in NLNG systems to propose strategies and policies to improve SCFP in NLNG networks.

The research employed clearly established methods and theories to reveal a novel taxonomy, a framework and a model for SCFP in NLNG systems. These constructs presented SCM practices, including *integration and collaboration*, *sourcing strategy, IT and automation, investment, sustainability* and *capacity development*, which should be designed and implemented together across NLNG supply chain networks to improve financial performance. This study revealed that SCM practices influence NLNG SCFP metrics, including *revenue, cost, working capital* and *assets utilisation*. Directions for future work in the area of LNG and energy SCF are suggested to overcome the limitations encountered in this study.

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Appendices

Appendix 1: Initial theoretical template

Supply chain financial performance drivers

1. *Sourcing strategy*
    - 1.1. Constantly weighing the costs associated with make-or-buy decisions
        - 1.1.1. Focus on key competitive advantages
            - 1.1.1.1. Win-win situation for all involving parties
    - 1.2. Transaction cost economy
        - 1.2.1. Reduce production cost and increase flexibility
            - 1.2.1.1. No need to commit to asset specificity
    - 1.3. Purchasing and supply management
        - 1.3.1. Enhances customer's responsiveness
    - 1.4. Production innovation
    - 1.5. Process innovation
    - 1.6. Asset specificity
    - 1.7. Outsourcing
        - 1.7.1. Cost effectiveness
        - 1.7.2. Characteristics of outsourcing contracts
            - 1.7.2.1. Vendor's location
            - 1.7.2.2. The connection between the outsourcing and outsourced companies
            - 1.7.2.3. Partnerships and contract duration
        - 1.7.3. Certain outsourcing decisions
            - 1.7.3.1. Core business outsourcing
            - 1.7.3.2. Overseas outsourcing
            - 1.7.3.3. Short-term outsourcing
        - 1.7.4. Outsourcing announcements

2. *Information technology*
    - 2.1. Transaction cost economics
        - 2.1.1. Enhance supply chain collaboration
        - 2.1.2. Reduce coordination cost
            - 2.1.2.1. Increase visibility and transparency
    - 2.2. IT department's technical skill
    - 2.3. Management support
    - 2.4. IT plan utilisation
    - 2.5. IT investment at strategic business unit
        - 2.5.1. IT advancement
        - 2.5.2. IT alignment
        - 2.5.3. E-commerce capability
    - 2.6. IT based supply chain management systems
    - 2.7. Announcement on the adaptation of supply chain technology

3. *System integration*
    - 3.1. Coordination of business processes within and beyond the firm's boundary
    - 3.2. Enterprise resource planning
        - 3.2.1. Internal and external information flow integration
        - 3.2.2. Management functions within and across supply chain participants
    - 3.3. Supply chain management system
        - 3.3.1. Coordination of business within and outside the firm's boundary
    - 3.4. Customer relationship management
    - 3.5. Integration with IT infrastructure
        - 3.5.1. Higher-order supply chain management process capability
            - 3.5.1.1. Information sharing
            - 3.5.1.2. Customer
            - 3.5.1.3. Quality

3.5.1.4. Supply
3.6. IT alignment and inter-firm system integration
3.7. Announcement to form or join industry exchanges
3.8. Resource-based view and knowledge-based view
3.8.1. Integration of supply chain knowledge
3.8.2. Integration of supply chain strategy

4. External relationships
4.1. Collaboration
4.1.1. Collaborative advantage
4.1.2. Supplier management
4.1.3. Strategic supplier partnership
4.1.4. Customer relationship management
4.1.5. Level of information sharing
4.1.6. Quality of information sharing
4.1.7. Postponement
4.1.8. Competitive advantage
4.1.9. Concentration supply chains
4.1.10. Contingency and configuration perspective
4.1.11. Mutual trust and commitment
4.1.11.1. Asset investments
4.1.11.2. Behaviour uncertainty
4.1.11.3. Commitment level
4.1.11.4. Information sharing
4.1.12. Partners reputation
4.1.13. Building an effective relationship between supply chain participants
4.1.13.1. Supply chain flexibility

Supply chain financial performance measures

5. Revenue growth
5.1. Sales growth
5.2. Profitability
5.2.1. Market value

6. Operating cost reduction
6.1. Reduction in cost of goods sold
6.2. Reduction in selling and general and administrative expenses
6.3. Transaction risks
6.4. Profitability

7. Working capital efficiency
7.1. Liquidity
7.1.1. Time compression and order-to-cash conversion cycle
7.1.1.1. Speedy delivery of complete orders and ensure invoice accuracy
7.1.1.2. Reduction in account payable
7.1.2. Inventory and procurement rationalisation practices
7.1.3. Profitability

Source: Author

Appendix 2: Final theoretical template

Supply chain financial performance drivers

1. *Sourcing strategy*
   - 1.1. Constantly weighing the costs associated with make-or-buy decisions
     - 1.1.1. Focus on key competitive advantages
       - 1.1.1.1. Win-win situation for all involving parties
   - 1.2. Transaction cost economics
     - 1.2.1. Reduce production cost and increase flexibility
   - 1.3. Purchasing and supply management strategies
     - 1.3.1. Supply chain integration
       - 1.3.1.1. Inter-organisational integration and collaboration
         - 1.3.1.1.1. Flexibility
         - 1.3.1.1.2. Reliable delivery
         - 1.3.1.1.3. Responsiveness
       - 1.3.1.2. Internal-facing firm level business performance
         - 1.3.1.2.1. Cost
         - 1.3.1.2.2. Asset
     - 1.3.2. Cross-functional integration and functional coordination
       - 1.3.2.1. Purchasing performance
     - 1.3.3. Flexibility and reliability of suppliers
   - 1.4. Outsourcing and subcontracting-in
     - 1.4.1. Operational innovativeness

2. *IT and automation*
   - 2.1. Investment in supply chain management IT, implementation, alignment and integration
     - 2.1.1. E-collaboration tools and e-business applications such as enterprise resource planning, electronic data interchange, radio-frequency identification
       - 2.1.1.1. Business-to-business/vertical supply chain integration
       - 2.1.1.2. Reduce the frequency and intensity of supply chain glitches
       - 2.1.1.3. Improvement in knowledge intensive capabilities
         - 2.1.1.3.1. Operational or functional improvements
     - 2.1.2. Just-in-time processes
       - 2.1.2.1. Customer order and manufacturing cycle/material procurement cycle
         - 2.1.2.1.1. Physical plant layout and use
         - 2.1.2.1.2. Material handling
         - 2.1.2.1.3. Quality handling
         - 2.1.2.1.4. Manufacturing efficiency
   - 2.2. Transaction cost economics
     - 2.2.1. Enhance supply chain collaboration
     - 2.2.2. Reduce administrative and coordination costs
       - 2.2.2.1. Electronic ordering system
     - 2.2.3. Information exchange
       - 2.2.3.1. Increase visibility and transparency
   - 2.3. Resource-based view
     - 2.3.1. Higher-order supply chain management process capability such as electronic ordering system
     - 2.3.2. Information sharing and access to inventory information
   - 2.4. Innovative solutions
     - 2.4.1. Electronic ordering system

3. *Integration and collaboration*
   - 3.1. Intra-firm integration and integrated supply chain management system
     - 3.1.1. Total management support
       - 3.1.1.1. Management functions within and across supply chain participants
     - 3.1.2. Internal information flow integration
       - 3.1.2.1. Organisational learning theory
         - 3.1.2.1.1. External integration

3.1.2.2. Resource-based view
3.1.2.3. Cross-functional integration
3.1.2.3.1. Minimise supply chain process variability
3.1.2.4. Access to inventory information
3.1.2.4.1. Inventory data integrity
3.1.3. Supply chain knowledge, capability and strategy
3.1.3.1. Strategic choice theory
3.1.3.2. Knowledge-based view
3.1.4. Operational performance
3.2. Inter-firm collaboration and integrated partnership
3.2.1. Total Management support
3.2.2. Supply chain reliability
3.2.3. Bargaining power between companies
3.2.4. Supply chain information flow integration
3.2.5. Long-term relationship with principal customer
3.2.6. Degree of consolidation
3.2.7. Trust, cooperation and commitment
3.2.8. Customer / distributor integration
3.2.8.1. Distribution network structure
3.2.8.1.1. Customer service
3.2.8.2. Mutual dependence with customer
3.2.8.2.1. Commitment and trust
3.2.8.2.2. Resource dependency
3.2.8.2.3. Economic benefits diminish beyond certain point
3.2.8.3. Process integration
3.2.8.4. Information sharing
3.2.9. Supplier integration
3.2.9.1. Mutual dependency with supplier
3.2.9.1.1. Resource dependency
3.2.9.2. System and process integration
3.2.9.3. Operational performance
3.2.9.3.1. Time
3.2.9.3.2. Relationship quality
3.2.9.3.3. Natural culture
3.2.9.4. Customer relationship
3.2.10. Supply chain fit: strategic consistencies between the products' supply and demand
3.2.10.1. Supply chain coordination
3.2.10.2. Buyer/supplier collaboration
3.2.10.3. Information sharing and visibility
3.2.11. External customer-firm-supplier relation management
3.2.11.1. Internal contextual factors: human resource management, quality data...
3.2.12. Knowledge sharing
3.2.12.1. Knowledge-based view
3.2.12.2. Operational Innovation
3.2.12.3. Reduce Lead-time variance
3.2.12.4. Reduce bullwhip effect
3.2.12.5. Reduce the frequency and intensity of supply chain glitches
3.3. Supply chain flexibility
3.3.1. Environmental uncertainty
3.3.1.1. Lead-time variance
3.3.1.2. Collaborative transportation management
3.3.2. Technical complexity
3.3.3. Mutual understanding
3.3.3.1. Supply chain adaptability/resilience
3.3.3.1.1. Supply chain preparedness
3.3.3.1.2. Supply chain alertness
3.3.3.1.3. Supply chain agility
3.3.3.1.4. Lean supply chain
3.4. Integration with IT infrastructure
3.4.1. Alignment

3.4.2. Resource-based view
3.4.3. Supply chain analytic information technology
3.4.4. E-collaborations/e-business/business-to-business supply chain integration

3.4.4.1. Upstream and downstream integration
3.4.4.1.1. Information about material flow
3.4.4.1.2. Document sharing
3.4.4.1.3. Collaborative forecasting
3.4.4.1.4. Collaborative planning
3.4.4.1.5. Automated Payments

4. *Sustainability*
4.1. Social dimension
4.1.1. Stakeholder theory
4.1.2. Stakeholder requirement
4.1.2.1. Good management theory
4.1.2.1.1. Corporate social responsibility lowers cost and risk
4.1.2.1.2. Corporate social responsibility creates competitive advantage
4.1.2.1.3. Corporate social responsibility boosts legitimacy and reputation
4.1.2.1.4. Corporate social responsibility creates win – win situations for the company and society
4.1.2.2. Tax advantages
4.1.2.3. Attracts investment
4.1.3.Internal concerns
4.1.3.1. Slack resources theory
4.1.3.1.1. Ethical consideration
4.1.3.1.2. Employee satisfaction
4.1.3.1.3. Corporate social responsibility
4.1.3.1.4. Sustainable Supply chain partners, delivery, location and packaging
4.2. Environmental dimension
4.2.1. Natural resource-based view
4.2.1.1. Conservation and pollution prevention
4.2.1.1.1. Reduce risks and attracts investment
4.2.2.Stakeholder requirement
4.2.2.1. Green Supply chain management
4.2.2.2. Good management theory
4.2.2.2.1. Corporate social responsibility lowers cost and risk
4.2.2.2.2. Corporate social responsibility creates competitive advantage
4.2.2.2.3. Corporate social responsibility boosts legitimacy and reputation
4.2.2.2.4. Corporate social responsibility creates win – win situations for the company and society
4.2.2.2.5. ISO 14001
4.2.3. Internal considerations
4.2.3.1. Slack resources theory
4.2.3.1.1. Employee considerations
4.2.3.1.2. Ethical concerns
4.2.3.1.3. Sustainable partners, delivery, location and packaging
4.2.4. Minimise use of material, energy or water and eco-efficient solutions
4.2.4.1. Recycling, reuse and waste management
4.2.5.Green supply chain operations reference
4.2.6.Joint implementation of social and environmental strategies

Supply chain financial performance measures

5. *Revenue growth*
5.1. Increase shareholders value

- 5.1.1. Profitability
  - 5.1.1.1. Sales growth and sales productivity
  - 5.1.1.2. Cash generation
  - 5.1.1.3. Operating income

6. *Operating cost reduction*
   - 6.1. Increase shareholders value
     - 6.1.1. Profitability
       - 6.1.1.1. Sales productivity
       - 6.1.1.2. Reduction in selling, general and administrative expenses
       - 6.1.1.3. Reduction in transaction risks
     - 6.1.2. Tax minimisation
       - 6.1.2.1. After-tax free cash flow
         - 6.1.2.1.1. Assets location
         - 6.1.2.1.2. Different tax and tariff regimes

7. *Working capital efficiency*
   - 7.1. Increase shareholders value
     - 7.1.1. Profitability
     - 7.1.2. Liquidity
       - 7.1.2.1. Inventory management and inventory turnover
       - 7.1.2.2. Cash-to-cash cycle time

8. *Fixed asset utilisation*
   - 8.1. Medium term strategy of increasing shareholders value creation
   - 8.2. Operating performance
     - 8.2.1. Net sales from fixed-asset investments
       - 8.2.1.1. Minimise assets redundancy
       - 8.2.1.2. Investment efficiency
         - 8.2.1.2.1. Liquidity

Source: Author

Appendix 3: Questionnaire guide

Dear respondent
Please find below some broad definitions and guidelines on how to complete the questionnaires which you may find helpful

Terms	Broad Definition
Supply chain	For the purpose of this case study, supply chains are the various value streams within an LNG operation, which consist of material and equipment sourcing, feedgas supply, gas treatment, liquefaction, storage and shipment to an import terminal.
Financial Performance	This is a subjective measure of how well the LNG supply chain utilises assets from its primary mode of business to generate revenues. It is also used as a measure of a supply chain's overall financial wellbeing over a given period, and can be used to compare similar supply chains across the LNG industry.
Sourcing	This is related to how the LNG supply chain sources its materials, consumables and assets. It may be through direct purchase or outsourced via a third party logistics service provider.
Information technology and automation	The degree of utilisation of telecommunication technologies, machineries, software, applications and associated packages in the LNG supply chain.
Integration and collaboration	The degree of information, resources and financial integration internally between various divisions and units of the LNG Company, as well as external integration with other LNG supply chain participants.
Sustainability	The extent to which LNG supply chains sustain their survival and growth taking into consideration social and environmental concerns, while remaining profitable.
Revenue growth	An LNG supply chain strategy towards increasing output and maximizing price.
Cost reduction	The extent to which an LNG supply chain minimises its operating cost.
Working capital efficiency	The level of efficiency in terms of the management of receivables, payables and inventory to improve the liquidity position of an LNG supply chain.
Fixed asset utilisation	The efficient use of assets such as LNG trains, storage, vessels and information technology within the LNG supply chain.

SECTION	**Closed questionnaire – Type A**

Pairwise comparison of LNG supply chain financial performance measures

- Please **tick one option** from the pairwise questionnaire below to indicate the relative importance of the following **NLNG supply chain financial performance measures** based on your opinion

- **Example** when comparing **"*revenue growth*"** to **"*cost reduction*" as measures of performance** if you think that:

- **"revenue growth"** is slightly more important than **"*cost reduction*", please tick "3" on the left hand side,**

- **"cost reduction"** is absolutely more important than **"*revenue growth*", please tick "9" on the right hand side**

- if you think that **the two options are equally important, please tick "1"**
- Please do not respond to any option that you do not understand or do not have an opinion about
- **Key:** 1=Equally important, 3=Slightly more important, 5=Strongly more important, 7=Demonstrably more importance, 9=Absolutely more importance

Importance or preference of one LNG supply chain **financial measurement criteria** over another

<-- Important | Equal | Important-->

	9	7	5	3	1	3	5	7	9	
Revenue growth	○	○	○	●	○	○	○	○	○	Cost reduction
Revenue growth	○	○	○	○	○	○	○	○	●	Cost reduction
Revenue growth	○	○	○	○	●	○	○	○	○	Cost reduction

Paired comparison of LNG supply chain financial performance drivers with respect to LNG supply chain financial performance measures

- Please **tick one option** in each row of the pairwise questionnaire below to indicate the **relative importance of the following NLNG supply chain financial performance drivers** in relation to the NLNG supply chain financial performance measures based on your opinion.
- **Example** if in terms of **"*revenue growth*"**, you think that ***"sourcing"*** is slightly more important than **"*sustainability*", please tick "3" on the left hand side,**
- if you think that "***sustainability***" is absolutely more important than **"*sourcing*", please tick "9" on the right hand side,**
- and if you **think that the two options are equal please tick "1".**
- You should skip any option that you do not understand or do not have an opinion about
- **Key:** 1=Equally important, 3=Slightly more important, 5=Strongly more important, 7=Demonstrably more importance, 9=Absolutely more importance

This section measures the extent to which the following supply chain financial performance drivers **influence revenue growth in LNG supply chains**

<-- Important | Equal | Important-->

	9	7	5	3	1	3	5	7	9	
Sourcing	○	○	○	●	○	○	○	○	○	Sustainability
Sourcing	○	○	○	○	○	○	○	○	●	Sustainability
Sourcing	○	○	○	○	●	○	○	○	○	Sustainability

Appendix 4: Semi-structured interview questionnaire

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Semi-structured interview questions

To enhance the quality of this study, please, could you answer the following open ended questions **based on your personal experience and opinion** about NLNG supply chain financial performance.

1. From your experience in few words describe the key factors of chain finance in the LNG industry.

2. In your own opinion what are the components of supply chain financial performance in the LNG industry?

3. What are the challenges affecting LNG supply chain financial performance?

4. What do you think is the cause of slow growth in terms of LNG production and export capacity by some major LNG exporting countries?

5. In your own opinion what factors may prevent investors from LNG investment in some LNG exporting countries?

6. Does supply chain flexibility affect LNG supply chain financial performance?

7. What are the benefits and the drawbacks of both LNG long-term contracts and spot sales?

8. To what extent can the security situation in a country affect its LNG supply chain finance?

9. What are the strategies and policies that can enhance LNG supply chain financial performance?

10. Are there any other matters or opinions which can enhance the quality of this study?

Location Data

Location: (51.464294433594, -0.01190185546875)

Source: GeoIP Estimation

Appendix 5: AHP survey questionnaire

. **Analytical hierarchy process questionnaire**

Pairwise comparison of LNG supply chain financial performance measures

§ Please **tick one option** from the pairwise questionnaire below to indicate the **relative importance** of the following **NLNG supply chain financial performance measures** based on your opinion

§ **Example** when comparing **"revenue growth"** to **"cost reduction" as measures of performance** if you think that:

§ **"revenue growth"** is slightly more important than **"cost reduction", *please tick "3"* on the left hand side,**

§ **"cost reduction"** is absolutely more important than **"revenue growth", *please tick "9"* on the right hand side**

§ if you think that **the two options are equally important, *please tick "1"***

§ Please do not respond to any option that you do not understand or do not have an opinion about

§ **Key:** 1=Equally important, 3=Slightly more important, 5=Strongly more important, 7=Demonstrably more importance, 9=Absolutely more importance

1. **Importance or preference** of one LNG supply chain **financial measurement criteria** over another

<-- Important | Equal | Important-->

	9	7	5	3	1	3	5	7	9	
Revenue growth	○	○	○	○	○	●	○	○	○	Cost reduction
Revenue growth	○	○	○	○	●	○	○	○	○	Working capital efficiency
Revenue growth	○	○	○	○	○	○	○	●	○	Fixed asset utilisation
Cost reduction	○	○	○	●	○	○	○	○	○	Working capital efficiency
Cost reduction	○	○	○	○	○	●	○	○	○	Fixed asset utilisation
Working capital efficiency	○	○	○	○	●	○	○	○	○	Fixed asset utilisation

.

Paired comparison of LNG supply chain financial performance drivers with respect to LNG supply chain financial performance measures

§ Please **tick one option** in each row of the pairwise questionnaire below to indicate the **relative importance of the following NLNG supply chain financial performance drivers** in relation to the NLNG supply chain financial performance measures based on your opinion

§ **Example** if in terms of **"revenue growth"**, you think that **"sourcing"** is slightly more important than **"sustainability", *please tick "3"* on the left hand side,**

§ if you think that **"sustainability"** is absolutely more important than **"sourcing"**, ***please tick "9" on the right hand side,***

§ and if you **think that the two options are equal *please tick "1"*.**

§ You should skip any option that you do not understand or do not have an opinion about

§ **Key:** 1=Equally important, 3=Slightly more important, 5=Strongly more important, 7=Demonstrably more importance, 9=Absolutely more importance

2i.
This section measures the extent to which the following supply chain financial performance drivers **influence revenue growth in LNG supply chains**

<-- Important | Equal | Important-->

	9	7	5	3	1	3	5	7	9	
Sourcing	○	○	○	◉	○	○	○	○	○	IT & automation
Sourcing	○	○	○	○	◉	○	○	○	○	Integration & collaboration
Sourcing	○	◉	○	○	○	○	○	○	○	Sustainability
IT & automation	○	○	○	○	○	◉	○	○	○	Integration & collaboration
IT & automation	○	○	○	◉	○	○	○	○	○	Sustainability
Integration & collaboration	○	○	○	○	◉	○	○	○	○	Sustainability

2ii.
This section measures the extent to which the following supply chain financial performance drivers **influence cost reduction in LNG supply chain**

<-- Important | Equal | Important-->

	9	7	5	3	1	3	5	7	9	
Sourcing	○	○	○	○	○	◉	○	○	○	IT & automation
Sourcing	○	○	○	○	◉	○	○	○	○	Integration & collaboration
Sourcing	○	○	○	○	○	○	○	◉	○	Sustainability
IT & automation	○	○	○	◉	○	○	○	○	○	Integration & collaboration
IT & automation	○	○	○	○	○	◉	○	○	○	Sustainability
Integration & collaboration	○	○	○	○	◉	○	○	○	○	Sustainability

2iii.
This section measures the extent to which the following supply chain financial performance drivers **influence working capital efficiency in the LNG supply chain**

<-- Important | Equal | Important-->

	9	7	5	3	1	3	5	7	9	
Sourcing	○	○	○	○	○	●	○	○	○	IT & automation
Sourcing	○	○	○	○	●	○	○	○	○	Integration & collaboration
Sourcing	○	○	○	○	○	○	○	●	○	Sustainability
IT & automation	○	○	○	●	○	○	○	○	○	Integration & collaboration
IT & automation	○	○	○	○	○	●	○	○	○	Sustainability
Integration & collaboration	○	○	○	○	●	○	○	○	○	Sustainability

2iv.
This section measures the extent to which the following supply chain financial performance drivers **influence fixed asset utilisation in the LNG supply chain**

<-- Important | Equal | Important-->

	9	7	5	3	1	3	5	7	9	
Sourcing	○	○	○	○	●	○	○	○	○	IT & automation
Sourcing	○	○	○	●	○	○	○	○	○	Integration & collaboration
Sourcing	○	○	○	●	○	○	○	○	○	Sustainability
IT & automation	○	○	○	●	○	○	○	○	○	Integration & collaboration
IT & automation	○	○	○	●	○	○	○	○	○	Sustainability
Integration & collaboration	○	○	○	○	●	○	○	○	○	Sustainability

Location Data

Appendix 6: Likert-scale survey questionnaire

. **Likert-scale questionnaire**

§ From the following supply chain financial performance drivers (**sourcing strategy, information technology, integration and collaborations, and sustainability),** please select the option that best matches your view

§ You should skip any option that you do not understand or do not have an opinion about

§ **Key:** 1=Strongly disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly disagree

1.
Please tick one option to show how far you agree that the following factors influence **sourcing strategy** as a driver of LNG supply chain financial performance

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Desire to retain control of operations	○	○	●	○	○
Cost effectiveness	○	○	○	○	●
Reliability of delivery	○	○	○	○	●
Innovativeness in production and processes	○	○	○	●	○

2.
Please tick one option to show how far you agree that the following factors influence **information technology and automation** as a driver of LNG supply chain financial performance

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Information flow	○	○	○	○	●
Delivery performance	○	○	○	●	○
Supply chain integration	○	○	○	○	●
Resource utilisation	○	○	●	○	○
Innovative financial solution	○	○	○	●	○
Cost effectiveness	○	○	○	●	○

3.
Please tick one option to show how far you agree that the following factors influence **integration and collaboration** as a driver for LNG supply chain financial performance

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Internal integration	○	○	○	○	●
External integration	○	○	○	●	○

Information flow	○	○	○	○	●
Financial risk exposure	○	○	●	○	○
Trust, cooperation and commitment	○	○	○	●	○
Integrated information technology infrastructure	○	○	○	●	○
Knowledge sharing	○	○	○	●	○
Resource sharing	○	○	○	●	○
Transaction costs minimisation	○	○	○	●	○
Inventory management	○	○	○	●	○

4.

Please tick one option to show how far you agree that the following factors influence **sustainability** as a driver for LNG supply chain financial performance

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Drive for corporate responsibility and ethical consideration	○	○	○	○	●
Employee satisfaction	○	○	○	●	○
Health and safety agenda	○	○	○	○	●
Pollution, carbon footprint and other environmental considerations	○	○	○	○	●
Economic benefits	○	○	●	○	○
Financial risk management	○	●	○	○	○
Tax advantages	○	●	○	○	○
Investment opportunities	○	○	○	●	○
Compliance with ISO14001	○	○	○	○	●
Brand image and reputation	○	○	○	●	○

Location Data

Appendix 7: Ethical approval

RESEARCH WITH PLYMOUTH UNIVERSITY

Ref: FREC1617.44
Date: 28 June, 2017

Dear Nasiru

Ethical Approval Application No: FREC1617.44
Title: Optimising Financial Performance in Nigeria Liquefied Natural Gas Supply Chains

The Faculty Research Ethics Committee has considered the ethical approval form and is fully satisfied that the project complies with Plymouth University's ethical standards for research involving human participants.

Approval is for the duration of the project. However, please resubmit your application to the committee if the information provided in the form alters or is likely to alter significantly.

We would like to wish you good luck with your research project.

Yours sincerely

(Sent as email attachment)

Dr James Benhin
Chair
Faculty Research Ethics Committee
Faculty of Business

Faculty of Business
University of Plymouth
Drake Circus
Plymouth
Devon PL4 8AA United Kingdom

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Appendix 8: Research information sheet

RESEARCH INFORMATION SHEET

1. Research Project Title:

Supply Chain Financial Performance in Liquefied Natural Gas Systems

2. Research Invitation

You are being asked to take part in a research study on "financial performance in Nigeria liquefied natural gas (NLNG) supply chains". Before you decide whether or not to participate, it is important that you understand why the research is being done and what it will involve. This information sheet explains the aims of the study. If there is anything that is unclear, or if you would like more information, please ask us. Your participation in this study is entirely voluntary.

3. What is the aim of this study?

The main aim of this research is to study LNG supply chain management in the context of improving supply chain financial performance in NLNG networks.

4. Why have I been chosen?

You have been chosen because we believe that you have the right expertise in the area of NLNG supply chain. We also believe that the findings from this will have useful influences for NLNG supply chain which you might be interested in.

5. Do I have to take part?

No. It is up to you to decide whether or not you wish to participate in this study. Your participation is entirely voluntary. If you agree to take part, we will then ask you to sign a consent form. You are free to withdraw any time without giving a reason.

6. What will happen to me if I take part?

If you choose to take part in this study, we will be asking for your opinion on NLNG supply chain processes through survey and interview, which will last about an hour. There are not any right or wrong answers because we just want to hear about your opinion.

7. What are the possible benefits of taking part?

By participating in this study you will help to improve our understanding of the NLNG supply chain. You will have the opportunity to provide your expert opinion on current supply chain processes. The information we collect from you will contribute to our project samples and reach findings about improving NLNG supply chain systems. If you are interested, we would be happy to provide you with a summary of research findings.

8. Will my taking part in this project be kept confidential?

All information collected about you during the project will be kept strictly confidential. You will not be able to be identified in any reports or publications. None the less, the name of your agencies may be acknowledged in the publications where appropriate with your permission.

9. Will I be recorded, and how will the recorded media be used?

You are not going to be recorded using voice recorder; however, surveys and interviews are web-based which the transcripts of your responses will be automatically recorded at the end of the session.

10. Who is organising and funding the research?

Petroleum Technology Development Fund (PTDF), Nigeria.

12. Contact for further information

If you have any questions, please do not hesitate to contact PhD student Nasiru Zubairu: nasiru.zubairu@plymouth.ac.uk or nasir.zubairu@gmail.com If you are dissatisfied with the way the research is conducted, please contact the Director of Studies in the first instance: john.dinwoodie@plymouth.ac.uk. If you feel the problem has not been resolved please contact the Faculty of Business Research Ethics Committee: FOBResearch@plymouth.ac.uk

Appendix 9: Consent form

CONSENT FORM

Research project title

Supply chain financial performance in liquefied natural gas systems

Name and email of researcher

Nasiru Zubairu, nasiru.zubairu@plymouth.ac.uk

Note

Participants have the right to withdraw from the study at any time without giving any reason.

Please read the following statements and, if you agree tick the corresponding box to confirm agreement:

1. I confirm that I have read the information sheet for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐

2. I understand that my participation is voluntary and that I am free to withdraw from the study at any time without giving any reason. ☐

3. I understand that my data will be treated confidentially and any publication from this work will report only anonymised quotes that does not identify me. ☐

4. I freely agree to take part in the above study. ☐

______________	______________	______________
Name of Participant	Date	Signature

Appendix 10: Confidentiality agreement

Nigeria LNG Limited

CONFIDENTIALITY AGREEMENT

This Agreement is made this 5th day of March 2018

Between:

Nigeria LNG Limited, a company incorporated in Nigeria, under the laws of Nigeria, having its registered office at NLNG Complex, Amadi Creek Eastern Bypass, Port Harcourt, Rivers State Nigeria (hereinafter referred to as the 'Company' which expression shall where the context so admits include its successors-in-title and assigns) of the one part,

And

Nasiru Zubairu, a PhD student in the Department of International Shipping, Logistics and Operations at Plymouth Business School, University of Plymouth, PL4 8AA Plymouth, United Kingdom (hereinafter called the "Researcher") of the other part, your expert opinion on current supply chain processes.

WHEREAS

1. The Researcher is desirous of conducting as part of his research on Optimising Financial Performance in Nigeria Liquefied Natural Gas Limited Supply Chain, some data collection on the Company and therefore requires access to administer survey regarding experts opinion and collect documents relevant to Nigeria Liquefied Natural Gas Limited supply chain (All such documents or information are hereinafter called "Confidential Information and/or Documents" and they are more particularly defined below).

2. Company has agreed to grant the Researcher's request subject to the terms and conditions that are set out in this Agreement.

3. As a condition precedent to disclosure of the requested Confidential Information, the Researcher agrees to treat any Confidential Information and /or document provided by or on behalf of Company in accordance with the provisions of this Agreement.

THIS AGREEMENT WITNESETH AS FOLLOWS:

DEFINITIONS

In this Agreement, the Highlighted words and phrases shall have the meaning ascribed to them below:

Nigeria LNG Limited

Confidential Information and/or Documents" shall mean data and information in whatever form concerning Company's institutional, technological and strategic past, position, pattern, plan, perspective and ploy. Confidential Information and/or Documents shall also include but shall not be limited to all financial, technical, operational, commercial, planning, staff management and other information, data, experience and know-how, together with any analyses, compilations, forecasts studies in whatever form prepared by or on behalf of Company or its Associated Companies, agents or Representatives.

However Confidential Information shall not include information which:

(a) Is generally available to the public other than as a result of a disclosure by the Researcher,

(b) Is or becomes available to Researcher on a non-confidential basis from a source which is not prohibited from disclosing such information,

(c) Can be shown by written records to have been in the possession of the Researcher prior to or at the time it was provided to Researcher by or on behalf of Company.

Representative" means a director, an employee, or professional advisor of the Company

1. The Researcher hereby acknowledge that he is being granted access to the Confidential Information solely for the purpose of his research on Optimising Financial Performance in Nigeria Liquefied Natural Gas Limited Supply Chain.

   The Confidentiality of such Information shall be maintained by the Researcher and the Researcher agrees as follows:

   a. Subject to paragraph 1 (g) below, not at any time, whether during or after the end of the Researcher's visit with Company (unless as expressly authorised by Company in this Agreement) to disclose to any person or to make use of any such Confidential Information.

   b. To deliver to Company at the end of the Researcher's visiting period on each of the visiting days, any documents, computer records and any other records belonging to NLNG to which he has been granted access.

   c. Not at any time make a copy of the whole or any part of any document, computer record or any other record belonging to Company. He may take notes in the course of the interviews and he can make an abstract,

Nigeria LNG Limited

summary or précis of the whole or any part of any document, computer record or any other record belonging to Company.

Any work arising from such note, abstract, summary or précis shall be cleared by Company prior to disclosure to any third party.

d. Not to use any Confidential Information in a manner which may be prejudicial to or which may harm the interests of Company.

e. In the event that the Researcher becomes legally compelled to disclose any of the Confidential Information, the Research will promptly inform Company so that it may seek a protective order or other appropriate remedy and/or waive compliance with the provisions of this Agreement. In the event that such protective order or other remedy is not obtained, only that portion of the Confidential Information which is legally required shall be revealed and the Researcher will exercise his best efforts to obtain reliable assurances that confidential treatment will be accorded by the Authority to the Confidential Information.

f. Company shall have the right in its sole discretion, without giving reasons therefore at any time to terminate the visit and require the return of any Confidential Information it has disclosed to the Researcher under this Agreement.

g. Notwithstanding any provisions of this Agreement to the contrary, the Researcher may disclose any Confidential Information to his supervisors and examiners in the Department of International Shipping, Logistics and Operations of University of Plymouth, without Company's prior consent provided that the Researcher shall remain responsible for ensuring that such supervisors and examiners treat such Confidential Information in accordance with the provisions of this Agreement.

2. The Parties further agree as follows:

a. This Agreement shall be governed by and construed in accordance with the laws of Federal Republic of Nigeria and any disputes relating to it shall be dealt with by Arbitration under the Arbitration and Conciliation Act, Cap. A18. Laws of the Federation of Nigeria 2004 and any subsequent amendments thereof.

b. This Agreement may not be assigned.

Nigeria LNG Limited

c. The obligations as to confidentiality and secrecy contained in this Agreement shall continue in force for 1 (one) year after the end of the Visit.

IN WITNESS WHEREOF the parties hereto have executed this Agreement

Signed by the RESEARCHER

NAME **Nasiru Zubairu** SIGNATURE

DESIGNATION **PhD Student at University of Plymouth, UK**

In the presence of:

NAME Auwal Mohammed SIGNATURE

DESIGNATION Head of Administration at Asta-Barka Nigeria Limited, Gwandal Centre, Fria Close, Wuse 2, Abuja, Nigeria.

Signed for and on behalf of Nigeria LNG Limited By

NAME Sani Ahmed SIGNATURE

DESIGNATION GRC

In the presence of:

NAME Nasir Jafre SIGNATURE

DESIGNATION Snr. Compliance officer – Business Integrity

Appendix 11: Summary of AHP analysis for overall NLNG group

Pairwise comparison matrix				
Criteria	C1	C2	C3	C4
C1	1.00	1.30	1.80	1.32
C2	0.77	1.00	1.61	1.92
C3	0.56	0.62	1.00	0.83
C4	0.76	0.52	1.21	1.00
Total	3.08	3.44	5.61	5.06

Normalisation matrix						
Criteria	C1	C2	C3	C4	Average	Consistency
C1	0.32	0.38	0.32	0.26	0.3206	4.0391
C2	0.25	0.29	0.29	0.38	0.3013	4.0453
C3	0.18	0.18	0.18	0.16	0.1756	4.0363
C4	0.25	0.15	0.21	0.20	0.2025	4.0242
Total	1	1	1	1	λ	**4.0362**
					CI	**0.0121**
					RI	**0.9000**
					CR	**0.0134**

CI = (λmax – *n*) / (*n* – 1)

CR = CI/RI

Number of Criteria	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Paired comparison matrix C1				
Alternatives	A1	A2	A3	A4
A1	1.00	1.92	0.86	0.90
A2	0.52	1.00	0.56	1.19
A3	1.17	1.79	1.00	1.38
A4	1.12	0.84	0.72	1.00
Total	3.81	5.54	3.14	4.47

Normalisation matrix C1						
Alternatives	C1	C2	C3	C4	Priory vector	Consistency
A1	0.26	0.35	0.27	0.20	0.2705	4.0907
A2	0.14	0.18	0.18	0.27	0.1906	4.0685
A3	0.31	0.32	0.32	0.31	0.3142	4.0776
A4	0.29	0.15	0.23	0.22	0.2247	4.0671
Total	1	1	1	1	λ	**4.0759**
					CI	**0.0253**
					RI	**0.9000**
					CR	**0.0281**

Paired comparison matrix C2				
Alternatives	A1	A2	A3	A4
A1	1.00	1.29	1.13	1.37
A2	0.78	1.00	0.58	1.40
A3	0.88	1.71	1.00	1.87
A4	0.73	0.71	0.53	1.00
Total	3.39	4.71	3.25	5.64

Normalisation matrix C2						
Alternatives	A1	A2	A3	A4	Priory vector	Consistency
A1	0.30	0.27	0.35	0.24	0.2901	4.0361
A2	0.23	0.21	0.18	0.25	0.2174	4.0262
A3	0.26	0.36	0.31	0.33	0.3155	4.0384
A4	0.22	0.15	0.16	0.18	0.1770	4.0232
Total	1	1	1	1	λ	**4.0310**
					CI	**0.0103**
					RI	**0.9000**
					CR	**0.0115**

Paired comparison matrix C3				
Alternatives	A1	A2	A3	A4
A1	1.00	1.33	1.22	1.31
A2	0.75	1.00	0.93	0.99
A3	0.82	1.07	1.00	1.38
A4	0.76	1.01	0.72	1.00
Total	3.33	4.42	3.88	4.68

Normalisation matrix C3						
Alternatives	A1	A2	A3	A4	Priory vector	Consistency
A1	0.30	0.30	0.31	0.28	0.2992	4.0086
A2	0.23	0.23	0.24	0.21	0.2258	4.0087
A3	0.25	0.24	0.26	0.30	0.2605	4.0092
A4	0.23	0.23	0.19	0.21	0.2145	4.0067
Total	1	1	1	1	λ	**4.0083**
					CI	**0.0028**
					RI	**0.9000**
					CR	**0.0031**

Paired comparison matrix C4				
Alternatives	A1	A2	A3	A4
A1	1.00	0.76	0.97	0.97
A2	1.32	1.00	1.06	1.35
A3	1.03	0.94	1.00	0.81
A4	1.03	0.74	1.23	1.00
Total	4.37	3.44	4.26	4.14

Normalisation matrix C3						
Alternatives	A1	A2	A3	A4	Priory vector	Consistency
A1	0.23	0.22	0.23	0.24	0.2282	4.0178
A2	0.30	0.29	0.25	0.33	0.2916	4.0187
A3	0.24	0.27	0.23	0.20	0.2352	4.0160
A4	0.23	0.22	0.29	0.24	0.2451	4.0173
Total	1	1	1	1	λ	**4.0175**
					CI	**0.0058**
					RI	**0.9000**
					CR	**0.0065**

Weighted average rating					
	C1	C2	C3	C4	Composite weight
Weight	0.3206	0.3013	0.1756	0.2025	
A1	0.2705	0.2901	0.2992	0.2282	0.2729
A2	0.1906	0.2174	0.2258	0.2916	0.2253
A3	0.3142	0.3155	0.2605	0.2352	0.2892
A4	0.2247	0.1770	0.2145	0.2451	0.2127

Overall consistency of the NLNG group hierarchy:

$$\overline{CR} = \frac{\sum_i w_i CI_i}{\sum_i w_i RI_i}$$

$$= \frac{0.0121(1)+0.0253(0.3206)+0.0103(0.3013)+0.0028(0.1756)+0.0058(0.2025)}{0.9(1)+0.9(0.3206)+0.9(0.3013)+0.9(0.1756)+0.9(0.2025)}$$

= 0.0139 < 0.1 (acceptable)

Appendix 12: Summary of AHP analysis for MD sub-group

Pairwise comparison matrix				
Criteria	C1	C2	C3	C4
C1	1.00	1.73	3.71	2.28
C2	0.58	1.00	1.63	2.59
C3	0.27	0.61	1.00	2.14
C4	0.44	0.39	0.47	1.00
Total	2.29	3.73	6.80	8.01

Normalisation matrix						
Criteria	C1	C2	C3	C4	Average	Consistency
C1	0.44	0.46	0.55	0.28	0.4328	4.2199
C2	0.25	0.27	0.24	0.32	0.2707	4.1390
C3	0.12	0.16	0.15	0.27	0.1742	4.1268
C4	0.19	0.10	0.07	0.12	0.1222	4.0747
Total	1	1	1	1	λ	**4.1401**
					CI	**0.0467**
					RI	**0.9000**
					CR	**0.0519**

Paired comparison matrix C1				
Alternatives	A1	A2	A3	A4
A1	1.00	2.14	1.32	1.06
A2	0.47	1.00	0.81	0.92
A3	0.76	1.24	1.00	1.63
A4	0.94	1.09	0.61	1.00
Total	3.17	5.46	3.74	4.61

Normalisation matrix C1						
Alternatives	C1	C2	C3	C4	Priory vector	Consistency
A1	0.32	0.39	0.35	0.23	0.32	4.07
A2	0.15	0.18	0.22	0.20	0.19	4.07
A3	0.24	0.23	0.27	0.35	0.27	4.06
A4	0.30	0.20	0.16	0.22	0.22	4.07
Total	1	1	1	1	λ	**4.07**
					CI	**0.02**
					RI	**0.90**
					CR	**0.02**

Paired comparison matrix C2				
Alternatives	A1	A2	A3	A4
A1	1.00	1.97	1.32	1.32
A2	0.51	1.00	0.39	0.51
A3	0.76	2.59	1.00	1.00
A4	0.76	1.97	1.00	1.00
Total	3.03	7.53	3.70	3.82

Normalisation matrix C2						
Alternatives	A1	A2	A3	A4	Priory vector	Consistency
A1	0.33	0.26	0.36	0.34	0.32	4.03
A2	0.17	0.13	0.10	0.13	0.13	4.02
A3	0.25	0.34	0.27	0.26	0.28	4.03
A4	0.25	0.26	0.27	0.26	0.26	4.03
Total	1	1	1	1	λ	**4.03**
					CI	**0.01**
					RI	**0.90**
					CR	**0.01**

Paired comparison matrix C3				
Alternatives	A1	A2	A3	A4
A1	1.00	1.63	1.00	1.16
A2	0.61	1.00	0.58	0.44
A3	1.00	1.73	1.00	1.32
A4	0.86	2.28	0.76	1.00
Total	3.48	6.64	3.34	3.91

Normalisation matrix C3						
Alternatives	A1	A2	A3	A4	Priory vector	Consistency
A1	0.29	0.25	0.30	0.30	0.28	4.04
A2	0.18	0.15	0.17	0.11	0.15	4.02
A3	0.29	0.26	0.30	0.34	0.30	4.04
A4	0.25	0.34	0.23	0.26	0.27	4.04
Total	1	1	1	1	λ	**4.04**
					CI	**0.01**
					RI	**0.90**
					CR	**0.01**

Paired comparison matrix C4				
Alternatives	A1	A2	A3	A4
A1	1.00	1.00	0.35	0.66
A2	1.00	1.00	0.88	0.88
A3	2.82	1.14	1.00	1.50
A4	1.52	1.14	0.67	1.00
Total	6.34	4.27	2.90	4.03

Normalisation matrix C3						
Alternatives	A1	A2	A3	A4	Priory vector	Consistency
A1	0.16	0.23	0.12	0.16	0.17	4.05
A2	0.16	0.23	0.30	0.22	0.23	4.06
A3	0.44	0.27	0.34	0.37	0.36	4.10
A4	0.24	0.27	0.23	0.25	0.25	4.07
Total	1	1	1	1	λ	**4.07**
					CI	**0.02**
					RI	**0.90**
					CR	**0.03**

Weighted average rating					
	C1	C2	C3	C4	Composite weight
Weight	0.4328	0.2707	0.1742	0.1222	
A1	0.3226	0.3228	0.2821	0.1692	0.2969
A2	0.1866	0.1345	0.1531	0.2283	0.1717
A3	0.2716	0.2817	0.2961	0.3564	0.2890
A4	0.2192	0.2610	0.2687	0.2462	0.2425

Overall consistency of the MD sub-group hierarchy:

$$\overline{CR} = \frac{\sum_i w_i CI_i}{\sum_i w_i RI_i}$$

= 0.0355 < 0.1 (acceptable)

Appendix 13: Summary of AHP analysis for Finance sub-group

Pairwise comparison matrix				
Criteria	C1	C2	C3	C4
C1	1.00	1.63	1.73	1.00
C2	0.61	1.00	1.52	2.59
C3	0.58	0.66	1.00	0.76
C4	1.00	0.39	1.32	1.00
Total	3.19	3.67	5.57	5.35

Normalisation matrix						
Criteria	C1	C2	C3	C4	Average	Consistency
C1	0.31	0.44	0.31	0.19	0.3136	4.1972
C2	0.19	0.27	0.27	0.48	0.3057	4.2623
C3	0.18	0.18	0.18	0.14	0.1703	4.1797
C4	0.31	0.11	0.24	0.19	0.2104	4.1166
Total	1	1	1	1	λ	**4.1890**
					CI	**0.0630**
					RI	**0.9000**
					CR	**0.0700**

Paired comparison matrix C1				
Alternatives	A1	A2	A3	A4
A1	1.00	3.87	2.14	1.73
A2	0.26	1.00	1.24	1.73
A3	0.47	0.81	1.00	1.50
A4	0.58	0.58	0.67	1.00
Total	2.30	6.26	5.05	5.96

Normalisation matrix C1						
Alternatives	C1	C2	C3	C4	Priory vector	Consistency
A1	0.43	0.62	0.42	0.29	0.44	4.35
A2	0.11	0.16	0.24	0.29	0.20	4.14
A3	0.20	0.13	0.20	0.25	0.20	4.12
A4	0.25	0.09	0.13	0.17	0.16	4.12
Total	1	1	1	1	λ	**4.18**
					CI	**0.06**
					RI	**0.90**
					CR	**0.07**

Paired comparison matrix C2				
Alternatives	A1	A2	A3	A4
A1	1.00	2.33	2.59	3.41
A2	0.43	1.00	0.58	1.29
A3	0.39	1.73	1.00	3.64
A4	0.29	0.77	0.27	1.00
Total	2.11	5.84	4.44	9.34

Normalisation matrix C2						
Alternatives	A1	A2	A3	A4	Priory vector	Consistency
A1	0.47	0.40	0.58	0.37	0.46	4.20
A2	0.20	0.17	0.13	0.14	0.16	4.08
A3	0.18	0.30	0.23	0.39	0.27	4.13
A4	0.14	0.13	0.06	0.11	0.11	4.02
Total	1	1	1	1	λ	**4.11**
					CI	**0.04**
					RI	**0.90**
					CR	**0.04**

Paired comparison matrix C3				
Alternatives	A1	A2	A3	A4
A1	1.00	2.65	1.32	1.73
A2	0.38	1.00	1.85	1.50
A3	0.76	0.54	1.00	1.73
A4	0.58	0.67	0.58	1.00
Total	2.72	4.86	4.74	5.96

Normalisation matrix C3						
Alternatives	A1	A2	A3	A4	Priory vector	Consistency
A1	0.37	0.54	0.28	0.29	0.37	4.30
A2	0.14	0.21	0.39	0.25	0.25	4.21
A3	0.28	0.11	0.21	0.29	0.22	4.10
A4	0.21	0.14	0.12	0.17	0.16	4.17
Total	1	1	1	1	λ	**4.20**
					CI	**0.07**
					RI	**0.90**
					CR	**0.07**

Paired comparison matrix C4				
Alternatives	A1	A2	A3	A4
A1	1.00	0.76	2.59	3.20
A2	1.32	1.00	0.94	1.16
A3	0.39	1.06	1.00	0.67
A4	0.31	0.86	1.50	1.00
Total	3.01	3.69	6.02	6.03

Normalisation matrix C3						
Alternatives	A1	A2	A3	A4	Priory vector	Consistency
A1	0.33	0.21	0.43	0.53	0.37	4.34
A2	0.44	0.27	0.16	0.19	0.26	4.31
A3	0.13	0.29	0.17	0.11	0.17	4.18
A4	0.10	0.23	0.25	0.17	0.19	4.21
Total	1	1	1	1	λ	**4.26**
					CI	**0.09**
					RI	**0.90**
					CR	**0.10**

Weighted average rating					
	C1	C2	C3	C4	Composite weight
Weight	0.3136	0.3057	0.1703	0.2104	
A1	0.4420	0.4553	0.3703	0.3747	0.4197
A2	0.2019	0.1608	0.2465	0.2639	0.2100
A3	0.1953	0.2736	0.2232	0.1734	0.2194
A4	0.1608	0.1102	0.1600	0.1880	0.1509

Overall consistency of the Finance sub-group hierarchy:

$$\overline{CR} = \frac{\sum_i w_i CI_i}{\sum_i w_i RI_i}$$

= 0.0682 < 0.1 (acceptable)

Appendix 14: Summary of AHP analysis for Production sub-group

Pairwise comparison matrix				
Criteria	C1	C2	C3	C4
C1	1.00	1.21	1.73	1.50
C2	0.83	1.00	1.50	1.16
C3	0.58	0.67	1.00	0.81
C4	0.67	0.86	1.24	1.00
Total	3.07	3.74	5.46	4.46

Normalisation matrix						
Criteria	C1	C2	C3	C4	Average	Consistency
C1	0.33	0.32	0.32	0.34	0.3252	4.0009
C2	0.27	0.27	0.27	0.26	0.2674	4.0007
C3	0.19	0.18	0.18	0.18	0.1827	4.0007
C4	0.22	0.23	0.23	0.22	0.2247	4.0008
Total	1	1	1	1	λ	**4.0008**
					CI	**0.0003**
					RI	**0.9000**
					CR	**0.0003**

Paired comparison matrix C1				
Alternatives	A1	A2	A3	A4
A1	1.00	1.40	0.81	0.61
A2	0.71	1.00	0.39	0.88
A3	1.24	2.59	1.00	0.67
A4	1.63	1.14	1.50	1.00
Total	4.58	6.13	3.69	3.16

Normalisation matrix C1						
Alternatives	C1	C2	C3	C4	Priory vector	Consistency
A1	0.22	0.23	0.22	0.19	0.22	4.15
A2	0.16	0.16	0.10	0.28	0.18	4.10
A3	0.27	0.42	0.27	0.21	0.29	4.17
A4	0.36	0.19	0.41	0.32	0.32	4.13
Total	1	1	1	1	λ	**4.14**
					CI	**0.05**
					RI	**0.90**
					CR	**0.05**

Paired comparison matrix C2				
Alternatives	A1	A2	A3	A4
A1	1.00	1.24	1.32	0.65
A2	0.81	1.00	0.76	1.06
A3	0.76	1.32	1.00	1.32
A4	1.53	0.94	0.76	1.00
Total	4.10	4.49	3.84	4.04

Normalisation matrix C2						
Alternatives	A1	A2	A3	A4	Priory vector	Consistency
A1	0.24	0.28	0.34	0.16	0.26	4.09
A2	0.20	0.22	0.20	0.26	0.22	4.10
A3	0.19	0.29	0.26	0.33	0.27	4.09
A4	0.37	0.21	0.20	0.25	0.26	4.12
Total	1	1	1	1	λ	**4.10**
					CI	**0.03**
					RI	**0.90**
					CR	**0.04**

Paired comparison matrix C3				
Alternatives	A1	A2	A3	A4
A1	1	2	2	2
A2	1	1	1	1
A3	0	1	1	1
A4	0	1	1	1
Total	2.55	4.52	5.46	5.02

Normalisation matrix C3						
Alternatives	A1	A2	A3	A4	Priory vector	Consistency
A1	0.39	0.36	0.39	0.43	0.39	4.02
A2	0.24	0.22	0.24	0.18	0.22	4.02
A3	0.18	0.17	0.18	0.20	0.18	4.02
A4	0.18	0.25	0.18	0.20	0.20	4.02
Total	1	1	1	1	λ	**4.02**
					CI	**0.01**
					RI	**0.90**
					CR	**0.01**

Paired comparison matrix C4				
Alternatives	A1	A2	A3	A4
A1	1.00	2.14	2.33	2.33
A2	0.47	1.00	1.77	2.01
A3	0.43	0.57	1.00	3.48
A4	0.43	0.50	0.29	1.00
Total	2.33	4.20	5.39	8.82

Normalisation matrix C3						
Alternatives	A1	A2	A3	A4	Priory vector	Consistency
A1	0.25	0.64	0.70	0.29	0.47	4.19
A2	0.12	0.30	0.53	0.25	0.30	4.01
A3	0.11	0.17	0.30	0.44	0.25	4.08
A4	0.11	0.15	0.09	0.13	0.12	4.62
Total	1	1	2	1	λ	**4.23**
					CI	**0.08**
					RI	**0.90**
					CR	**0.08**

Weighted average rating					
	C1	C2	C3	C4	Composite weight
Weight	0.3252	0.2674	0.1827	0.2247	
A1	0.2152	0.2562	0.3927	0.4705	0.3159
A2	0.1755	0.2205	0.2197	0.2997	0.2235
A3	0.2938	0.2663	0.1834	0.2530	0.2571
A4	0.3155	0.2570	0.2042	0.1169	0.2349

Overall consistency of the Production sub-group hierarchy:

$$\overline{CR} = \frac{\sum_i w_i CI_i}{\sum_i w_i RI_i}$$

= 0.0235 < 0.1 (acceptable)

Appendix 15: Summary of AHP analysis for Shipping sub-group

Pairwise comparison matrix				
Criteria	C1	C2	C3	C4
C1	1.00	0.75	5.00	5.92
C2	1.34	1.00	3.87	5.00
C3	0.20	0.26	1.00	0.65
C4	0.17	0.20	1.53	1.00
Total	2.71	2.20	11.40	12.57

Normalisation matrix						
Criteria	C1	C2	C3	C4	Average	Consistency
C1	0.37	0.34	0.44	0.47	0.4041	4.1427
C2	0.49	0.45	0.34	0.40	0.4216	4.1329
C3	0.07	0.12	0.09	0.05	0.0827	4.0195
C4	0.06	0.09	0.13	0.08	0.0917	4.0429
Total	1	1	1	1	λ	**4.0845**
					CI	**0.0282**
					RI	**0.9000**
					CR	**0.0313**

Paired comparison matrix C1				
Alternatives	A1	A2	A3	A4
A1	1.00	0.26	0.26	0.38
A2	3.87	1.00	0.38	1.00
A3	3.87	2.65	1.00	4.58
A4	2.65	1.00	0.22	1.00
Total	11.39	4.90	1.85	6.96

Normalisation matrix C1						
Alternatives	C1	C2	C3	C4	Priory vector	Consistency
A1	0.09	0.05	0.14	0.05	0.08	4.08
A2	0.34	0.20	0.20	0.14	0.22	4.11
A3	0.34	0.54	0.54	0.66	0.52	4.30
A4	0.23	0.20	0.12	0.14	0.17	4.19
Total	1	1	1	1	λ	**4.17**
					CI	**0.06**
					RI	**0.90**
					CR	**0.06**

Paired comparison matrix C2				
Alternatives	A1	A2	A3	A4
A1	1.00	0.13	0.14	1.00
A2	7.94	1.00	0.38	5.00
A3	7.00	2.65	1.00	5.92
A4	1.00	0.20	0.17	1.00
Total	16.94	3.97	1.69	12.92

Normalisation matrix C2						
Alternatives	A1	A2	A3	A4	Priory vector	Consistency
A1	0.06	0.03	0.08	0.08	0.06	4.00
A2	0.47	0.25	0.22	0.39	0.33	4.19
A3	0.41	0.67	0.59	0.46	0.53	4.28
A4	0.06	0.05	0.10	0.08	0.07	4.06
Total	1	1	1	1	λ	**4.13**
					CI	**0.04**
					RI	**0.90**
					CR	**0.05**

Paired comparison matrix C3				
Alternatives	A1	A2	A3	A4
A1	1.00	0.45	0.33	0.33
A2	2.24	1.00	1.00	2.24
A3	3.00	1.00	1.00	3.87
A4	3.00	0.45	0.26	1.00
Total	9.24	2.89	2.59	7.44

Normalisation matrix C3						
Alternatives	A1	A2	A3	A4	Priory vector	Consistency
A1	0.11	0.15	0.13	0.04	0.11	4.06
A2	0.24	0.35	0.39	0.30	0.32	4.26
A3	0.32	0.35	0.39	0.52	0.39	4.39
A4	0.32	0.15	0.10	0.13	0.18	4.20
Total	1	1	1	1	λ	**4.23**
					CI	**0.08**
					RI	**0.90**
					CR	**0.08**

Paired comparison matrix C4				
Alternatives	A1	A2	A3	A4
A1	1.00	0.38	3.87	0.38
A2	2.65	1.00	2.24	0.38
A3	0.26	0.45	1.00	0.17
A4	2.65	2.65	5.92	1.00
Total	6.55	4.47	13.03	1.92

Normalisation matrix C3						
Alternatives	A1	A2	A3	A4	Priory vector	Consistency
A1	0.15	0.08	0.30	0.20	0.18	4.14
A2	0.40	0.22	0.17	0.20	0.25	4.37
A3	0.04	0.10	0.08	0.09	0.08	4.18
A4	0.40	0.59	0.45	0.52	0.49	4.23
Total	1	1	1	1	λ	**4.23**
					CI	**0.08**
					RI	**0.90**

Weighted average rating					
	C1	C2	C3	C4	Composite weight
Weight	0.4041	0.4216	0.0827	0.0917	
A1	0.0835	0.0632	0.1090	0.1827	0.0861
A2	0.2228	0.3328	0.3185	0.2489	0.2795
A3	0.5193	0.5323	0.3941	0.0760	0.4738
A4	0.1744	0.0717	0.1783	0.4924	0.1606

Overall consistency of the Shipping sub-group hierarchy:

$$\overline{CR} = \frac{\sum_i w_i CI_i}{\sum_i w_i RI_i}$$

= 0.0465 < 0.1 (acceptable)

Appendix 16: Executive summary of quantitative findings

SUPPLY CHAIN FINANCIAL PERFORMANCE IN LIQUEFIED NATURAL GAS SYSTEMS

STUDY PHASE TWO EXECUTIVE SUMMARY

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In study phase one, systematic literature study established *revenue, cost, working capital* and *fixed asset utilisation* as supply chain financial performance (SCFP) measurement criteria. On the other hand *sourcing strategy*, *information technology (IT) and automation, integration and collaboration* and *sustainability* emerged as supply chain management (SCM) strategies which if appropriately implemented and safeguarded will drive competitive business survival and growth while creating value for investors.

This executive summary is derived from study phase two findings, which prioritised the SCFP drivers and measures established in study phase one in NLNG supply chain systems using quantitative survey data collected from experts at NLNG. The prioritisation was conducted using analytical hierarchy process (AHP) as a multi criteria decision-making (MCDM) method to measure the relative weight of each of the identified SCFP drivers on NLNG SCFP. To evaluate the relative weight of each of the identified SCFP drivers on NLNG's financial performance, a total of 32 experts were approached for expert opinion, out of which 23 responded to the AHP surveys conducted. All responses were considered for group decision analysis and the majority for sub-group or divisional analysis, depending on the number of respondents from a given division.

Findings present *revenue growth* as the most important factor for consideration when measuring SCFP in NLNG. *Cost reduction* is the second most important criterion for measuring SCFP in NLNG. Cumulatively, *revenue growth* and *cost reduction* represents over 62% of the SCFP measuring criteria in NLNG. The third ranked criterion for measuring SCFP in NLNG is *fixed asset utilisation,* which increased the accumulated weight to 82%. *Working capital efficiency* was ranked as the fourth and considered as the least important SCFP measurement criterion for by experts at NLNG.

Integration and collaboration in NLNG supply chain systems comprise of internal integration between divisions, departments and units, and external integration with suppliers and customers. Collaborative strategies include working with customers under long-term contracts to divert cargos to locations where revenues could be optimised. Amongst the SCFP drivers, *integration and collaboration* is the highest ranking SCFP capability in NLNG due to its superior influence on *revenue growth* and *cost reduction*, as well as a very good ranking in relation to *working capital efficiency* as measures for financial performance. This corroborated study phase one findings *where integration and collaboration* was the dominant driver of SCFP. Further analysis also revealed that the favourable ranking given to *integration and collaboration* was strongly influenced by the strongest preference given to this alternative by group decision-makers from the Shipping division. In addition, *integration and collaboration* is not the highest ranked alternative from the Managing Director (MD), Finance, and Production divisions; however, it was ranked second by decision-making sub-groups from these three divisions. This explains the reason why *integration and collaboration* was regarded as a key driver of SCFP by the bigger NLNG group.

Sourcing strategy in NLNG supply chains consist of decisions regarding *cost efficient* and reliable supply of assets, consumables, man power and most importantly Feedgas supply. Findings present *sourcing strategy* as the second ranked SCFP driver in NLNG. The high preference given to *sourcing strategy* resulted from its strong impact on top ranking SCFP measures, *revenue growth* and *cost reduction* in NLNG supply chain systems. In addition, findings established that *sourcing strategy* has the highest influence on *working capital efficiency*. The results contradicted study phase one findings where *sourcing strategy* is not as dominant as *IT and automation*, owing to the role of *IT and automation* as an enabler for *integration and collaboration*. Analysis also revealed that the second ranking given to *sourcing strategy* was strongly influenced by strongest preference given to this alternative by group decision-makers from MD, Production and especially Finance divisions. This could be associated to the well documented security threat facing NLNG Feedgas supply due to third party sabotage. Moreover, results revealed that the reason *sourcing strategy* was not the number one driver of SCFP in NLNG was strongly associated with the favourable ranking given to *integration and collaboration* by group decision-makers from the Shipping division.

IT and automation comprise of strategies regarding the IT systems that enable efficient communication within and across NLNG supply chain networks, as well as the deployment and maintenance of assets such as LNG trains, tanks and vessels to improve NLNG SCFP. *IT and automation* as a driver of SCFP in NLNG was ranked third by experts at NLNG. Although *IT and automation* was ranked third, it has the highest relationship with the third ranking SCFP measure, *fixed assets utilisation*. Further analysis has also shown that it was only the ranking by the Finance sub-group that conforms with the ranking by the NLNG group decision makers with respect to *IT and automation* as a driver of SCFP in NLNG. Although the Shipping division rankled *IT and automation* higher in second position, it was offset by the least ranking given from MD and Production divisions.

Sustainability strategy in NLNG supply chain deals with environmental and social issues such as compliant with HSSE and IS4001, as well community development related activities which lead to long-term sustainable supply chains survival and growth. Amongst the SCFP drivers, *sustainability* was given the least priority by practitioners at NLNG. The lowest preference accorded to *sustainability* was because it has the least influence on *cost reduction* and *working capital efficiency* in NLNG supply chain distribution system. Empirical results conformed to the findings of study phase one where *sustainability* was the least dominant driver of SCFP. Study phase one argued that sustainable supply chain operations are costly endeavours and their impact on SCFP can be undermined by state of the economy, size of the company, location and level of compliance by other supply chain participants. Despite *sustainability* being ranked last by the NLNG group decision-makers, MD, Production and Shipping Divisions ranked *sustainability* in NLNG supply chain as third. This was not surprising considering *sustainability* is at the core of NLNG mission and vision statements. Further non-compliance with *sustainability* dimensions can result in huge costs to NLNG supply chains or even damage some of its asset or caused a shutdown in the supply chains which is a major concern for Production and Shipping Divisions. LNG shipping is a value chain that is highly regulated due to environmental concerns such as pollution; social concerns such as welfare of crew; and economical concerns including loss of cargo, loss of vessel and fines.

In conclusion, amongst the established SCM practices, empirical results identified *integration and collaboration* as the most important driver of financial performance in NLNG supply chain, followed by *strategic sourcing*, and *technology and automation*. Findings present *sustainability* as the least ranking driver of SCFP in NLNG supply chain systems. These suggest that optimal levels of *integration* and *strategic sourcing* initiatives are essential to realise the full financial advantages of effective supply chain strategies in NLNG supply chain networks. These results are based on the aggregate response of all the 23 respondents at NLNG. However, collective analysis for key divisions at NLNG as sub-groups present different variation in priorities which could be attributed to the nature, roles, challenges and objectives of each division. Analysis of the collective response from experts at the MD and Production divisions regarding SCFP drivers in NLNG prioritised *sourcing strategy, integration and collaboration, sustainability,* and *IT and automation* as first, second, third and fourth. Findings from Finance division ranked *sourcing strategy, integration and collaboration, IT and automation* and *sustainability*, as first, second, third and fourth while analysis of Shipping division ranked *integration and collaboration, IT and automation, sustainability,* and *sourcing strategy*, as first, second, third and fourth respectively.

The SCFP drivers utilised in study phase two were established from extensive literature review in study phase one. This research is currently analysing text-based electronic interviews (TBEI) conducted with 15 professionals at NLNG in study phase three, to access tacit expert knowledge, experience and understanding of SCFP capabilities in NLNG systems. This will extend study phase two findings, by validating of some of the findings in study phase one and two, modifying some of the drivers as appropriate for SCFP in NLNG systems, as well as establish additional SCFP drivers specific to NLNG which will enhance the quality of this research. Study phase three will enable this study to achieve its ultimate objective, to propose strategies and policies to improve SCFP in NLNG.

Appendix 17: Initial empirical template

Supply chain financial performance drivers

1. *Feedgas supply*
    - 1.1. Security of gas supply
    - 1.2. Reliability and timely supply of feedgas
        - 1.2.1. Avoid plant down time
        - 1.2.2. Avoid tank tops
        - 1.2.3. Avoid failed deliveries
    - 1.3. Feedgas pricing mechanism
    - 1.4. Contracting and procurement strategy
        - 1.4.1. Provision of information
    - 1.5. Partnering with supplies
    - 1.6. Outsourcing of warehousing
        - 1.6.1. Reduce inventory impact on working capital

2. *Information technology and automation*
    - 2.1. Integration with suppliers
    - 2.2. Technological innovation
    - 2.3. Relative age/condition of the plant
        - 2.3.1. Asset reliability, integrity and utilisation
            - 2.3.1.1. Asset Maintenance
            - 2.3.1.2. Shipping
            - 2.3.1.3. Port terminal
                - 2.3.1.3.1. Customer expectation
    - 2.4. LNG vessels ownership
        - 2.4.1. Control of outbound logistics
        - 2.4.2. Cost effective shipping system
    - 2.5. Construction complexities

3. *Integration and collaboration*
    - 3.1. Partnering with supplies
        - 3.1.1. Flexibility
            - 3.1.1.1. Spot sales
                - 3.1.1.1.1. Especially in period of constrained supply market
        - 3.1.2. Communication
        - 3.1.3. LTCs
            - 3.1.3.1. Take-or-pay arrangements and strict fulfilment provision
                - 3.1.3.1.1. Supply chain stability and sustainability
                - 3.1.3.1.2. Platform for better operational and cash planning
            - 3.1.3.2. Reduces cost of project finance
            - 3.1.3.3. LTCs does not provide much flexibility like spot contracts
            - 3.1.3.4. Optimal delivery require mix of DOS and FOB
    - 3.2. Internal integration and collaboration
        - 3.2.1. Access to materials and utilisation data
    - 3.3. Mergers and acquisitions

4. *Investment strategy*
    - 4.1. Project economic viability
        - 4.1.1. Market volatility/changing global economic climate
            - 4.1.1.1. Low/slump in crude oil prices to which LNG price is indexed
                - 4.1.1.1.1. Price stability

4.1.1.2. Entrance of new players into the market
4.1.1.2.1. Growth in global LNG supply volumes influences gas prices
4.1.1.3. Growth in alternative energies
4.1.2. LTCs
4.1.2.1. Take-or-pay arrangements and strict fulfilment provision
4.1.2.1.1. Supply chain stability and sustainability
4.1.2.1.2. Platform for better operational and cash planning
4.1.2.2. Reduces cost of project finance
4.1.2.3. LTCs does not provide much flexibility like spot contracts
4.1.2.4. Optimal delivery require mix of DOS and FOB
4.1.3. Weak upstream investment in feedgas production
4.2. Socio-economic factors
4.2.1. Political stability
4.2.1.1. Security
4.2.1.1.1. Kidnappings and sea pirate activities
4.2.1.1.2. Security of gas supply
4.2.1.1.3. Port safety and marine security
4.2.1.1.4. Security of assets
4.2.1.1.5. FEED, FID and expansion projects delays (OK LNG, Brass LNG and NLNG Trains 7/8 are examples)
4.2.1.1.6. High insurance premium and similar costs
4.2.2. Government policies and regulatory requirements
4.2.2.1. Export vs domestic gas utilisation/Need to meet domestic gas demand
4.2.2.1.1. Ability to secure profitable LTCs
4.2.2.2. Taxes, levies, subsidies and other fiscal regimes
4.3. Access and cost of project finance
4.3.1. Requirement for counterpart funding
4.3.2. Cost vs return on investment
4.3.3. Mergers and acquisitions
4.4. Marketing strategy
4.5. Capacity development
4.5.1. Retention of knowledge base and sustained capacity development
4.5.2. Organisational culture

5. Sustainability

5.1. Social considerations
5.1.1. Security challenges
5.1.1.1. Kidnappings and sea pirate activities
5.2. Environmental considerations
5.2.1. Security challenges
5.2.1.1. Pollution as a result of leaks
5.3. Economic considerations
5.3.1. Security challenges
5.3.1.1. Feedgas supply
5.3.1.2. LNG shipment
5.3.1.2.1. Customer satisfaction
5.3.2. Customer expectations
5.3.3. Technological innovations
5.3.4. LTCs

SCFP measures

6. *Cost reduction*
    - 6.1. Feed gas price
        - 6.1.1. Cost of developing gas fields
    - 6.2. Construction cost
    - 6.3. Cost of goods, materials and services
    - 6.4. Insurance premium
    - 6.5. Assets maintenance costs
        - 6.5.1. Costs of spares and consumables
    - 6.6. Shipping costs
    - 6.7. Port charges
    - 6.8. Inventory costs
    - 6.9. Taxes and levies
    - 6.10. Finance cost
    - 6.11. ROI
    - 6.12. Profit
    - 6.13. EBIT

7. *Working capital efficiency*
    - 7.1. Advance funding to ensure timely supply of input materials
    - 7.2. Receivables management
    - 7.3. Inventory management
    - 7.4. Provision of information

8. *Asset utilisation*
    - 8.1. Asset integrity
        - 8.1.1. Asset maintenance
            - 8.1.1.1. Plant availability and reliability
            - 8.1.1.2. Avoid plant downtime
            - 8.1.1.3. Avoid tank tops
    - 8.2. ROI

9. *Revenue*
    - 9.1. Production capacity
        - 9.1.1. Avoid plant downtime
        - 9.1.2. Plant availability and reliability
    - 9.2. Global oversupply of LNG
    - 9.3. ROI
    - 9.4. Profit
    - 9.5. EBIT

Appendix 18: Final empirical template

Supply chain financial performance drivers

1. *Feedgas supply*
   - 1.1. Planning and demand management
   - 1.2. Security of gas supply
     - 1.2.1. Burying the pipeline deeper as a security method
   - 1.3. Reliability and timely supply of feedgas
     - 1.3.1. Avoid plant down time
     - 1.3.2. Avoid tank tops
     - 1.3.3. Avoid failed deliveries
   - 1.4. Feedgas pricing mechanism
   - 1.5. Contracting and procurement strategy
     - 1.5.1. Provision of information
   - 1.6. Partnering with supplies
   - 1.7. Procurement
   - 1.8. Outsourcing of warehousing
     - 1.8.1. Reduce inventory impact on working capital
   - 1.9. Limited number of suppliers/feed stock
     - 1.9.1. Reserve issues

2. *Information technology and automation*
   - 2.1. Integration with suppliers
   - 2.2. Technological innovation
   - 2.3. Relative age/condition of the plant
     - 2.3.1. Asset reliability, integrity and utilisation
       - 2.3.1.1. Asset Maintenance
       - 2.3.1.2. Shipping
       - 2.3.1.3. Port terminal
         - 2.3.1.3.1. Customer expectation
   - 2.4. LNG vessels ownership
     - 2.4.1. Control of outbound logistics
     - 2.4.2. Cost effective shipping system
   - 2.5. Construction complexities
     - 2.5.1.Infrastructural development

3. *Integration and collaboration*
   - 3.1. Partnering with supplies
     - 3.1.1. Flexibility
       - 3.1.1.1. Lead time
       - 3.1.1.2. Demand management
       - 3.1.1.3. Service delivery
       - 3.1.1.4. Spot sales
         - 3.1.1.4.1. Especially in period of constrained supply market
     - 3.1.2. Operation integration
       - 3.1.2.1. Use of IT
   - 3.2. Communication
   - 3.3. LTCs
     - 3.3.1. Take-or-pay arrangements and strict fulfilment provision
       - 3.3.1.1. Secure the sales of the products and supply chain stability and sustainability
       - 3.3.1.2. Platform for better operational and cash planning

3.3.2. Reduces cost/enhances opportunity for project finance
3.3.3. LTCs does not provide much flexibility like spot contracts
3.3.4. Spot sales does not protect the huge initial investment outlay
3.3.5. Optimal delivery require mix of DES and FOB
3.4. Risk sharing
3.5. Internal integration
3.5.1. Access to materials and utilisation data
3.6. Mergers and acquisitions / JVs
3.7. Trust
3.7.1. Access to finance
3.7.2. Sanctity of agreements
3.7.3. Commitment of investors

4. Investment strategy
4.1. Project economic viability
4.1.1. Market volatility/changing global economic climate
4.1.1.1. Low/slump in crude oil prices to which LNG price is indexed
4.1.1.1.1. Price stability
4.1.1.2. Competition and entry of new players into the market
4.1.1.3. Growth in global LNG supply volumes influences gas prices
4.1.1.4. Distance to major market
4.1.1.5. Growth in alternative energies
4.1.2. LTCs
4.1.2.1. Take-or-pay arrangements and strict fulfilment provision
4.1.2.1.1. Secure the sales of the products and supply chain stability and sustainability
4.1.2.1.2. Platform for better operational and cash planning
4.1.2.2. Reduces cost/ enhances opportunity for project finance
4.1.2.3. LTCs does not provide much flexibility like spot contracts
4.1.2.4. Spot sales does not protect the huge initial investment outlay
4.1.2.5. Optimal delivery require mix of DES and FOB
4.1.3. Weak upstream investment in feedgas production
4.1.3.1. Inadequate feedstock
4.2. Socio-economic factors
4.2.1. Political stability
4.2.1.1. Security
4.2.1.1.1. Kidnappings and sea pirate activities
4.2.1.1.2. Security of gas supply
4.2.1.1.3. Port safety and marine security
4.2.1.1.4. Security of assets
4.2.1.1.5. Projects delays
4.2.1.1.6. High insurance premium and similar costs
4.2.2. Policies and regulatory requirements
4.2.2.1. Export vs domestic gas utilisation/Need to meet domestic gas demand
4.2.2.1.1. Ability to secure profitable LTCs
4.2.2.2. Taxes, levies, subsidies and other fiscal regimes
4.2.2.2.1. Tax incentives
4.2.2.3. Corruption
4.2.2.4. Delays in clearance of goods
4.3. Access and cost of project finance
4.3.1. Requirement for counterpart funding
4.3.2. Cost vs return on investment

4.3.3. Mergers and acquisitions
4.3.4. Country credit rating
4.3.5. Risk sharing
4.4. Marketing strategy
4.4.1. JVs
4.4.2. Commitment of investors

5. Sustainability

5.1. Social considerations
5.1.1. Security challenges
5.1.1.1. Kidnappings and sea pirate activities
5.1.2. HSE
5.1.3. Community relation issues
5.2. Environmental considerations
5.2.1. Security challenges
5.2.1.1. Pollution as a result of leaks
5.2.2.HSE
5.2.3.Community relation issues
5.3. Economic considerations
5.3.1. Security challenges
5.3.1.1. Feedgas supply
5.3.1.2. LNG shipment
5.3.1.2.1. Service delivery
5.3.2. Customer expectations
5.3.3. Technological innovations
5.3.4. LTCs

6. Capacity development

6.1. Retention of knowledge base and sustained capacity development
6.2. Organisational culture
6.3. Local content capabilities
6.3.1. Indigenous capacity development
6.4. Security issues
6.4.1. Difficulty in getting foreign expat
6.5. Employment of youth with potentials

SCFP measures

7. Cost reduction

7.1. Planning cost
7.2. Feedgas price
7.2.1. Cost of developing gas fields
7.3. Security cost
7.4. Infrastructure cost
7.5. Cost of goods, materials and services
7.6. Production/liquefaction cost
7.7. Insurance premium
7.7.1. Additional insurance cover for high risk regions
7.8. Assets maintenance costs
7.8.1. Costs of spares and consumables
7.9. Shipping costs/port charges
7.9.1. Increase in crew wages in high risk regions

7.10. Inventory costs
7.11. Procurement and logistics costs
7.12. Taxes and levies
7.13. Finance cost
7.14. ROI
7.15. Profit
7.16. EBIT

8. *Working capital efficiency*
   8.1. Advance funding
   8.2. Receivables management
   8.3. Inventory management
   8.4. Provision of information
   8.5. Liquidity

9. *Asset utilisation*
   9.1. Asset integrity
      9.1.1. Asset maintenance
         9.1.1.1. Plant availability and reliability
         9.1.1.2. Avoid plant downtime
         9.1.1.3. Avoid tank tops
   9.2. ROI

10. *Revenue*
   10.1. Production capacity
   10.2. Loss of production
      10.2.1. Avoid plant downtime
      10.2.2. Plant availability and reliability
   10.3. Global oversupply of LNG
   10.4. ROI
   10.5. Profit
   10.6. EBIT
   10.7. Market share

Appendix 19: Executive summary of qualitative findings

SUPPLY CHAIN FINANCIAL PERFORMANCE IN LIQUEFIED NATURAL GAS SYSTEMS

STUDY PHASE THREE EXECUTIVE SUMMARY

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Study phase two revealed that amongst the supply chain financial performance (SCFP) drivers established in study phase one, *integration and collaboration* is the most important driver of financial performance in NLNG supply chain, followed by *sourcing strategy and information technology (IT) and automation,* and *sustainability* as the least ranking driver of SCFP in NLNG supply chain systems. These suggest that optimal levels of integration and strategic sourcing of feedstock are essential to realise the full financial advantages of effective supply chain strategies in NLNG supply chain networks.

This executive summary is derived from study phase three findings, which analysed qualitative text-based electronic interviews (TBEI) conducted with 15 professionals at NLNG, to access tacit expert knowledge, experience and understanding of SCFP capabilities in NLNG systems. Data were analysed using template analysis where themes were generated from sub-set of data which were later modified as more data emerged from the remaining transcripts. This phase extends study phase one and phase two findings by validating key supply chain strategies identified in study phase one that drive SCFP in NLNG and modifying one of the drivers to suit NLNG logistics systems. This study established two additional SCFP drivers specific to NLNG supply chain systems which enhanced the quality of this research.

In conformity with study phase one, study phase three established *revenue growth, cost reduction, working capital efficiency and asset utilisation* as key SCFP measures in NLNG systems. However, *cost* and *revenue* are the dominant criteria. This is consistent with study phase two findings where *revenue* and *cost* were prioritised as distance first and second SCFP measurement criteria in NLNG systems. First, *revenue growth* as a component of profitability is an important SCFP measure, it enhances return on investment (ROI) and increases shareholders wealth. Empirical findings suggest that *high revenue* associated with spot sales enhances NLNG SCFP, however, uninterrupted revenue streams associated with long-term contracts (LTC) provide more sustainable financial gains to NLNG supply chains. Results further established that gas transmission system (GTS) vandalism causes supply chain glitch, which results in *loss of potential revenue*. Second, *cost reduction* has positive influences for financial metrics in NLNG supply chains, including profit and ROI. *Costs* in NLNG supply chains include feedgas, maintenance, production, security, personnel, taxes, levies, exchange rates, insurance, planning, logistics, procurement and finance *costs* which have influences for financial performance. Third, empirical studies established that *reliability of feedstock* and the condition of the NLNG plant affect the rate of *asset utilisation*, which has influences on ROI and return on assets (ROA). Results revealed that SCFP drivers in NLNG such as *sourcing strategy, integration* and supply chain flexibility can be measured using *working capital efficiency,* which includes management of payables, receivables and inventory. Supply chain practices influence *working capital*, cash flows and liquidity in NLNG supply chain networks.

Template analysis identified *feedgas supply, IT and automation, integration and collaboration, sustainability, investment, and capacity development* as higher-order themes that drive SCFP in NLNG systems. *Sourcing strategy, IT automation, integration and collaboration and sustainability* remain similar to the findings of study phase one. However the term *feedgas supply* espouses *sourcing strategy* as an industry terminology for feedstock sourcing. *Investment* and *capacity development* are new higher-order themes which developed as further data emerges from empirical template analysis. *Investment strategy* entails purposive planning to attract *investment* into NLNG supply chain, which will enhance production capacity, competitiveness and financial performance. *Capacity development* on the other hand involves implementation of clearly defined policies and procedures for hiring, training and retention of labour force with relevant skills across all NLNG value chains. *Capacity development* improves labour productivity and competitiveness and financial performance.

Extant literature does not categorise *investment* as a SCM capability in study phase one, however, *investment* emerged from empirical interviews as a major driver of financial performance in NLNG distribution networks, largely due to the capital intensive nature of the industry and country peculiarities specific to NLNG supply chain systems. In addition, *investment* is the most dominant higher-order theme because of its influence on other higher-order supply chain capabilities, especially *IT and automation, capacity development and sustainability*. NLNG project feasibility, including market conditions, contracts and access to feedstock is a determinant for *investment* into NLNG supply chains. The liquefaction component of LNG supply chain which is at the core of the NLNG value chain is the most capital intensive, with key risks facing liquefaction projects including completion risk, supply risk, market risk, pricing risk and political risk. Socio-economic factors such as political stability, policies and regulatory requirements should be considered when developing an *investment* strategy to drive SCFP in NLNG logistics systems. It was established that access and cost of financing as well as marketing strategy also has influence on NLNG *investment*.

The emergence of *capacity development* as a key theme for SCFP in NLNG systems was not surprising due to the relevant knowhow required to operate in such a complex and sophisticated automated supply chain network. The levels of *investment*, technology implementation, integration intensity, environmental conditions and availability of skilled labour facilitate *capacity development* and retention. *Capacity development* enables other NLNG SCFP drivers such as *investment, integration, technology implementation and utilisation,* and *sustainability*. NLNG supply chains involve complex and risky operations such as management and manning of liquefaction trains, terminal operations and ship handling which all need a certain level of expertise to operate safely and efficiently to improve financial performance across NLNG supply chain systems. *Capacity development* and retention facilitates internal integration as well as external integration with suppliers and customers which enhances flow of information, material and finance within and across NLNG supply chain systems.

Template analysis revealed that to improve *capacity development* capability and enhance SCFP in NLNG systems, strategy should make provision for appropriate recruitment and training policies and funding. Analysis presented *investment* as the dominant financial performance driver in NLNG systems and revealed that *capacity development* attracts *investment* into NLNG supply chain systems.

In conclusion, study phase three identified *investment* and *capacity development* in addition to the established supply chain capabilities including *feedgas supply, integration and collaboration, IT and automation,* and *sustainability* as SCFP drivers in NLNG systems. Results suggest that effective implementation of these initiatives is essential to realise the full financial advantages of effective supply chain strategies in NLNG networks. To fully optimise financial performance, all the six initiatives should be employed across NLNG supply chain systems as none of the supply chain capabilities is a standalone driver of SCFP. Study phase three also confirmed *revenue growth, cost reduction, working capital efficiency and asset utilisation* as NLNG SCFP measures. These findings are based on the aggregate response of all the 15 respondents at NLNG.

Study phase three enabled this research to propose a framework for improving SCFP NLNG systems and facilitates this study to achieve its ultimate objective, to propose strategies and policies to improve SCFP in NLNG.