An Australian Case Study in Identifying Perceived Barriers to Innovation and Technology Transfer among Drilling Assets in CSG Infrastructures

A thesis submitted by

Daniel Davoodian
MBA, BEng (Civil), GDipBM, DipPM

For the award of

Doctor of Philosophy

2017

"Noah built his ark before it started raining;
it is very hard to build an ark under water."
Samsam Bakhtiari, National Iranian Oil Company
(ASPO 2008)

ABSTRACT

The drilling industry supply chain consists of global procurement, contract management, transport, storage, control measures and information flow. Factors that restrict the supply chain in the Australian drilling industry include internal (company-related and micro-economical) and external (geopolitical and macro-economical) drivers or barriers.

Through this research, a number of perceived barriers to innovation and technology transfer within the Australian drilling industry's supply chain network were identified. The causes of these barriers include internal forces, external forces and natural causes. The research has explored how and to what extent these barriers influence the Australian drilling industry.

The initial studies of the literature review indicated research gaps about the key barriers in Australian drilling. The first question was, Is Australia utilising the latest oil and gas technologies? This hypothesis was developed through the researcher's observation during ten years of oil and gas industry experience, that Australian drilling is not utilising the latest technologies. The results of the initial research were taken to local and international industry professionals for evaluation of the findings. The discrepancy in answers indicated a blind spot in the gathered data and statistics. Afterwards, interviewing over eighty participants globally illustrated that Australia is neither utilising nor innovating the latest technologies.

In order to address the barriers, the researcher has utilised supply chain models to evaluate the level of local and international collaboration between the different levels of the Australian drilling sector. Therefore, the next

hypothesis on the lack of collaboration on the local and international level, in Australian drilling, was shaped. Evaluating the local collaboration has raised another hypothesis the government does not provide sufficient support to allow the industry to innovate.

The concept of innovation and technology transfer can be confused with invention or the technology itself. The literature review considers both invention and innovation for research purposes. Although the analysis of innovation and technology transfer can provide exceptional benefits to the industry and firms by providing solutions to have a more efficient industry, the analysis does not deliver an in-depth view of the causes, effects and exact benefits of innovation in the industry.

This research was conducted through a case study approach using a chain of detailed qualitative data, data analysis and interviews to address the barriers to innovation in the drilling industry in Australia. Essentially, the research intends to deliver a deeper understanding of what exactly is happening, why it is happening, and to address the elements affecting innovation and technology transfer in the Australian oil and gas industry.

It has also been identified that although this research area is undertaken by private research institutions and R&D departments, only a small portion of the findings are being shared with the public. This is why the current literature lacks an in-depth understanding of the concept of innovation and technology transfer and motives for innovation in on-shore drilling assets. Consequently, the main research questions were designed and developed as below:

- To what extent does the Australian on-shore drilling industry utilise the latest technological innovations?

- What are the key influencing factors for innovation and technology transfer within the Australian on-shore drilling industry in terms of the supply chain and its operating environment?

- How do the key influencing factors create barriers to innovation and technology transfer?

- To what extent do the barriers influence innovation and technology transfer?

The current research aims to explore the innovation and technology transfer experience within the Australian oil and gas industry, specifically the on-shore drilling industry. The research initially focuses on gaining a deeper understanding of the supply chain and its drivers and then it flows into the supply chain of oil and gas. The research has identified a number of barriers to technology transfer, which have been shown to be the main influencing factors on technology transfer and innovation.

The research provides a number of significant findings and a holistic overview of the supply chain of Australian drilling in different levels. The multilevel analysis identifies the gaps, which have been developed into a number of hypotheses on the current barriers to innovation and technology transfer. The result of this research should help to identify and rectify barriers to have a more innovative drilling industry in Australia. By comparison of the Australian oil and gas industry with more innovative nations' oil and gas industries, possibilities for advancing the Australian drilling industry are suggested. The ultimate goal is to have an Australian drilling industry that is an exporter of the most advanced drilling technology to the global energy industry.

Further research should aim at developing this qualitative research to compare the Australian oil and gas industry and companies with other advanced oil and gas nations and firms. In addition, an in-depth comparative analysis can be done across the five top-performing countries in terms of innovation in order to identify the gaps and compare the Australian industry and the role of the government in dictating policies for the top performers.

Certification of Thesis

This thesis is entirely the work of Daniel Davoodian except where otherwise acknowledged. The work is original and has not previously been submitted for any other award, except where acknowledged.

Student’s and supervisors’ signatures of endorsement are held at USQ.

____________________ 17 October 2017

Signature of Daniel Davoodian Date

ENDORSEMENT

______________________________ _______________________

Signature of Dr Steven Goh Date

(Supervisor)

______________________________ _______________________

Signature of Dr David Thorpe Date

(Associate Supervisor)

Acknowledgements

Starting my PhD research was the beginning of a chain of events in my life, through which I have lost a lot, yet also gained a lot. One of my biggest challenges in the past six years was to work on the drilling rigs as a crew member. None of the theories and lessons that I had learned previously at work, school or in life had fully prepared me for the experience of working there. It was a different world, with its own rules and its own language. Through sweat, blood, tears, labour and anguish, I have finished my research study. This PhD research is my way of giving back for what I have learned from Australian drilling. I hope this research contributes to the future of a stronger Australian drilling industry.

In the course of these events, my life changed directions a few times. There were moments I felt lost but, in hindsight, I was apparently lost in the right direction. There were people standing by my side and supporting me however they could. The list is long but there are a few that I need to mention here. Firstly, my parents, who taught me everything but the phrase “give up.” They were two angels who gave up their own dreams to make my dreams come true. Thank you, Maman; thank you, Baba.

To my supervisors who supported me in all aspects while I adjusted to my new life decisions. They challenged me, picked me up after each setback, and pushed me forward. They taught me how to think and reminded me of my end goal when I struggled to see it myself. Thank you, Steve and thank you, David. I would also like to thank two very good people who helped me through very difficult moments in the past few years: Dr Raksasat and Captain Dashtianeh, who were more than friends in helping me stand up again and rebuild my life.

I would also like to thank my two angels who treated me as their own son. If it were not for them, this journey could not even have started: Bez and Badieh Faramand.

Last but not least, my special thank you to the Australian Commonwealth

Government contribution through the Research Training Scheme (RTS) for supporting my study. And my highest regards to the USQ Faculty of Health, Engineering and Science as well as the USQ Office of Research for paving the way for this journey.

Maman, look- I am finally a doctor!

Table of Contents

TABLE OF FIGURES

Glossary (ConocoPhillips 2015):[1]

American Petroleum Institute (API)

The American Petroleum Institute is the oil and gas industry's trade organization. API's research and engineering work provides a basis for establishing operating and safety standard issues and specifications for the manufacturing of oil field equipment and furnishes statistical and other information to related agencies.

Basin

A large, natural depression on the Earth's surface in which sediments, generally brought by water, accumulate.

BBL

One stock tank barrel, of 42 U.S. gallons liquid volume, used in reference to crude oil, bitumen, condensate or natural gas liquids

Bitumen

A highly viscous form of crude oil (greater than 10,000 centipoise-at room temperature) resembling cold molasses (at room temperature). Bitumen must be heated or combined with lighter hydrocarbons for it to be produced. Contains sulfur, metals and other non-hydrocarbons in its natural form.

British thermal unit (BTU)

The heat required to raise the temperature of a one-pound mass of water by one degree Fahrenheit.

Completion

The process of making a well ready to produce natural gas or oil. Completion involves installing permanent equipment, such as a wellhead, and often includes hydraulic fracturing.

[1] Adapted from ConocoPhillips glossary of oil and gas

Conventional resources

Discrete accumulations of hydrocarbons contained in rocks with relatively high matrix permeability, which normally have relatively high recovery factors.

Developed reserves

Reserves that can be expected to be recovered through existing wells with existing equipment and operating methods or in which the cost of the required equipment is relatively minor compared to the cost of a new well and, if extraction is by means other than a well, through installed equipment and infrastructure operational at the time of the reserves estimate.

Directional drilling

The application of special tools and techniques to drill a wellbore at a predetermined angle. Horizontal drilling is a form of directional drilling where the wellbore is ultimately drilled at +/- 90 degrees to the vertical direction.

Drilling rig

The machine used to drill a wellbore.

Dry gas

Dry gas is almost pure methane and occurs in the absence of liquid hydrocarbons or by processing natural gas to remove liquid hydrocarbons and impurities.

E&P

Exploration and Production.

Field

An area consisting of a single hydrocarbon reservoir or multiple geologically related reservoirs all grouped on or related to the same individual geological structure or stratigraphic condition.

Fossil fuel

A fuel source (such as oil, condensate, natural gas, natural gas liquids or coal) formed in the earth from plant or animal remains.

Floating production, storage and offloading (FPSO)

Provides alternative to pipeline to store oil production and load vessels for movement to markets.

Heavy oil

Crude oil with an API gravity less than 20°. Heavy oil generally does not flow easily due to its elevated viscosity (at room temperature).

Horizontal drilling

A drilling technique whereby a well is progressively turned from vertical to horizontal so as to allow for greater exposure to an oil or natural gas reservoir. Horizontal laterals can be more than a mile long (one mile is equal to roughly 1.6 kilometers). In general, longer exposure lengths allow for more oil and natural gas to be recovered from a well and often can reduce the number of wells required to develop a field, thereby minimizing surface disturbance. Horizontal drilling technology has been extensively used since the 1980s and is appropriate for many, but not all, developments.

Natural gas liquids (NGLs)

A general term for highly volatile liquid products separated from natural gas in a gas processing plant. NGLs include ethane, propane, butane and condensate.

Oil sands

Geologic formation comprised predominantly of sand grains and bitumen, a highly viscous form of crude oil.

Operator

The entity responsible for managing operations in a field or undeveloped acreage position.

Reserves

Estimated remaining quantities of oil and gas and related substances anticipated to be economically producible, as of a given date, by application of development projects to known accumulations. In addition, there must exist, or there must be a reasonable expectation that there will exist, the legal right to produce or a revenue interest in production, installed means of delivering oil and gas or related substances to market and all permits and financing required to implement the project.

Reservoir

A porous and permeable underground formation containing a natural accumulation of producible oil and/or gas that is confined by impermeable rock or water barriers and is individual and separate from other reservoirs.

Resources

Quantities of oil and gas estimated to exist in naturally occurring accumulations. A portion of the resources may be estimated to be recoverable, and another portion may be considered to be unrecoverable. Resources include both discovered and undiscovered accumulations.

Unconventional reservoirs

Reservoirs with permeability so low (generally less than 0.1 millidarcy) that horizontal hydraulically fractured stimulated wells or other advanced compilation techniques must be utilized to extract hydrocarbons at commercial rates. Shale reservoirs such as the Eagle Ford and Barnett, as well as tight reservoirs like the Bakken and Three Forks, both are examples of unconventional reservoirs.

Wellbore

The hole drilled by a drilling rig to explore or develop oil and/or natural gas. Also referred to as a well or borehole.

CHAPTER 1: INTRODUCTION

1.1 Background

The use of fossil fuel goes back thousands of years to the use of natural bitumen by the Sumerians and Mesopotamians (Library of Congress 2006). The utilisation of fossil fuel throughout history has evolved and reached its pinnacle with the oil and gas industry, which is currently the engine of the world economy. In the early twentieth century, oil replaced coal as the world's primary source of industrial power (David 1999). Just as oil and gas drive today's world economy, the control and availability of oil and gas played a major role in both world wars and still remains the critical fuel source that powers industry and transportation (Library of Congress 2006).

Since 2007, the oil and gas supply chain has been affected by the volatility of the global economy such as the global financial crisis and fluctuations in oil price. Accordingly, it is fundamental that companies within this industry utilise an effective business model that improves business performance, while reducing business costs (Plunkett Corporation Ltd 2010). As a result, managing innovation and technology transfer in the supply chain network has become imperative for every company to reach economic success. "*It is widely recognised that innovation is fundamental for long-term business success. Whether it occurs via technology or unique marketing arrangements, innovation has driven the world's successful businesses to even greater heights. Those that fail to innovate, sooner or later, fall by the wayside. Many of the world's leading organisations have continued to grow by constantly reinventing their products, their business and even their industry*" (Schwengler & Freeth 2006).

The present study poses an opportunity to address a research gap on the essence of supply chain management and technology applications in the Australian oil and gas industry. To investigate the development and innovation operations of the Australian oil and gas drilling supply chain, it is important to identify the elements that slow down the innovation progress. The other findings from the study, as discussed in Chapter 4, will provide an in-depth understanding of how the perceived barriers restrict the innovation and technology transfer within the Australian drilling industry's supply chain network. Also, the findings in Chapter 5 will provide an investigation into the relationship between the applications of technologies and the increase in the efficiency and performance of the supply chain system, which will enable companies in the industry to improve their supply chain management.

However, the initial stage of the study is to provide a holistic overview of the Australian drilling industry's supply chain, as discussed in Chapter 2. The overview indicates the gaps in the current literature about the Australian drilling sector, as well as introducing hypotheses that can result in valuable findings. Therefore, the chapter starts with the fundamentals of the supply chain and the introduction of supply chain models. These models provide tools for analysis of the current Australian oil and gas supply chain, in order to identify gaps.

The current research will significantly contribute to the existing body of knowledge about the supply chain of the Australian oil and gas drilling industry, by providing in-depth information on the drilling supply chain management practices, while concentrating on innovation and technology transfer. It is expected that the results of the study will assist practitioners in improving the supply chain portal and will broaden both theoretical and practical perspectives on the link between innovation sectors, engineering technologies and supply chain management.

This research aims to investigate the key challenges facing the Australian drilling industry's innovation and technology transfer from a technology management point of view. However, this research thesis has faced limitations in accessing data for a few reasons. One is that innovation and technology are sensitive topics in such a highly competitive industry. This creates a narrow corridor of publicly available data for investigations and findings.

On the other hand, the culture of the drilling industry in Australia rejects the idea that Australia may not be utilising the latest technologies. Therefore, this strong opinion has limited the further evaluation of research and development functions in the drilling sector for the researcher.

In this research, the perceived barriers to innovation and technology transfer in the Australian onshore drilling industry's operation and supply chain network will be explored. Figure 1.1 shows the conceptual framework of the research to review the industry, which will be discussed further in the literature review, Chapter 2.

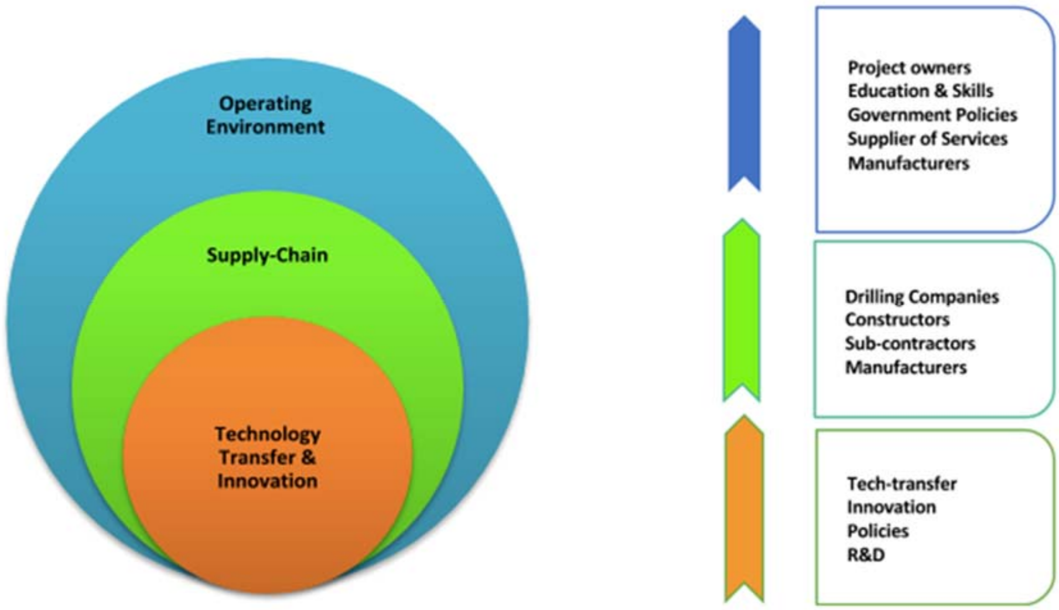


Figure 1.1: Conceptual framework to review the industry

The oil and gas industry's operating environment is an obscure and multidisciplinary environment within a vast area to research. The essential requirements of this research are to narrow down the area of study strategically to address the issues appropriately. Therefore, the research will focus on the onshore drilling side of the upstream section of the Australian domestic oil and gas industry. In order to further narrow down the area of research, the issues of innovation and technology transfer development will be focussed on. In future chapters, the relationship between the abovementioned layers and the role of each member of the industry is explained, in Chapter 2.

1.2 Research Aims and Objectives

The hypotheses proposed in this study have been raised through observation and active participation during the author's ten years of experience in the oil and gas industry and, specifically, the three years of work experience in Australian drilling operations. These hypotheses were quietly lamented in different forms by industry participants, hence the motivation for the author to propose this study. The findings of this study were presented to industry leaders and validated via interviews and focus groups. The research objectives are derived from the industry's practices and have been proved by utilising different methods. It appears that the Australian drilling industry is inefficient and has a poor innovation culture. Consequently, there is a need to gain a deeper insight to understand the link between supply chain management and all stages of activity in the operating environment. This is to identify the cause of the barriers to innovation and the barriers to utilising the latest technologies. The firm that performs well in this area should have a competitive advantage over a firm that overlooks the importance of the issue of technology transfer.

Companies need to integrate an effective supply chain with suitable engineering technologies in order to improve the business performance and reach the supply chain goals (Fisher 1997). In order to gain a deeper understanding of this issue, two main objectives were established:

1) To identify the perceived barriers to innovation within the Australian drilling industry's supply chain network.
2) To identify the perceived barriers to technology transfer within the Australian drilling industry's supply chain network.

1.3 Research Approach and Style

In this thesis, a case study research approach (which is based on qualitative research methodology) has been utilised to evaluate the ideas and innovations and challenge the theoretical assumptions. The researcher has undertaken academic research similar to an anthropologist researching and collecting data while working within the industry for over ten years. By both undertaking the academic research and working within the industry for ten years (at the office and also within the drilling operations on the rigs for three years), the researcher has taken a unique approach. The question of the barriers to technology and innovation was originally generated within the industry, amongst researchers and numerous international colleagues from major oil and gas firms. A qualitative approach has been employed in order to produce a more accurate result in the research and to validate the collected data. The research approach is further discussed in Chapter 3.

1.4 Ethical Clearance Approval

The research has obtained ethical clearance approval **H14REA162** as detailed in Appendix 2. Under the conditions of the consent for participants, there is a non-disclosure condition for any traceable identification including names, locations, photos, videos and discussion notes. These are withheld and to be destroyed at the end of the research.

1.5 Significant Contribution and Publications

This thesis explores and reports on a number of contributions to the field of research in innovation and technology transfer:

- "Technology transfer and innovation in oil and gas supply chain" published at OMICS International Journal of Petroleum & Environmental Engineering at Dubai International Conference and Expo on Oil and Gas as shown in Appendix 7 (Davoodian & Goh 2015).

- “Comparative analysis of Australian Innovation and the tyranny of distance”, under review for publication at the Australian Journal of Mechanical Engineering as shown in Appendix 8 (Davoodian & Goh 2016-under review).

As indicated, the supply chain of the energy industry is quite complex. The aim of this research is to help to develop a more innovative Australian drilling industry which is an exporter of technology to the world, rather than a consumer. The different layers of the supply chain study from technology to operations and the management will be reviewed. This study aims to contribute to the current body of knowledge of the Australian drilling industry as well as adding value to the supply chain of the industry.

1.6 Summary of Research Aim and Objectives

The main hypotheses were developed from the challenges that the author has either faced himself or observed industry colleagues battling. Consequently, the research objectives and questions were inspected through the operating environment and supply chain management, which led the research into innovation and technology transfer studies. The research objectives were developed utilising search tools such as the generalisation method and data triangulation in order to constantly refine the research objectives and the area of the study.

Following that, the findings were presented to industry leaders and validated via interviews and focus groups. The research objectives were derived from industry practices and were proved utilising different methods. It appears that that the Australian drilling industry is inefficient and has a poor innovation culture. Consequently, there is a need to gain a deeper insight to understand the link between supply chain management and all stages of activity in the operating environment. This is to identify the cause of the barriers to innovation and the barriers to utilising the latest technologies. The next section explains what can be expected from future chapters and where each activity is explained.

1.7 Summary of Chapters

In Chapter 2, the literature around the supply chain concept and the supply chain components are explored. A comprehensive overview of the supply chain in the oil and gas drilling sector from different levels is provided. Following that, different layers of the supply chain of the Australian oil and gas industry will be discussed in order to identify the influencing factors and drivers for innovation and technology transfer in this sector.

In Chapter 3 the methods utilised to establish the findings are explained in detail. The mix of qualitative and quantitative methods in the case study approach is covered and the triangulation mixed method is discussed. The development of the main research questions and the methods are reviewed.

The analysis of the quantitative and qualitative data collected is the main topic of Chapter 4. The implication and applications of the study, as well as the analysis of the study of the culture of the Australian drilling industry will be described in this chapter. One of the conclusions of the data analysis in Chapter 4 is that amongst all the internal barriers to innovation in the Australian drilling industry, a lack of government support for R&D purposes is recognised as the most significant influencing factor.

Chapter 5 will cover a comprehensive description of the research findings based on the data triangulations, individual observations and reflections as well the generalisation method. The researcher has also utilised personal reflections, which include ten years of observations, to form the initial questions and the hypothesis. One of the most significant discussions in Chapter 5 is the overview of the hierarchy of knowledge and the hierarchy of control in the drilling sector, which concludes in identifying the barriers to the flow of information between different levels of the Australian oil and gas industry.

The conclusion and overview of all materials gathered and discussed are reviewed in Chapter 6. This portion of the thesis is specifically designed to provide a holistic overview of the research journey. At the end, suggestions for future work are provided to future researchers in this field.

CHAPTER 2: LITERATURE REVIEW

The energy supply chain and, specifically, oil and gas assets are the lifeblood of today's society (Halldórsson & Svanberg 2013). Most people involved with the oil and gas industry would agree that the upstream oil and gas industry has become more technology-intensive over the years (Perrons 2014). As a result, supply chain management, strategies and resilience are areas that need to be contemplated for a better understanding of the industry's barriers. Most people's perception of supply chain management revolves around the flow of products through distribution channels. While the characteristics of the oil sector are similar to the gas sector, gas supply chain management is quite different in many ways (Jacoby 2012).

Supply chain management in the oil and gas industry closely resembles both supply chain management in the low-value process (as it has continuous production operation characteristics) and high-value process industries. Therefore, the oil and gas supply chain is distinctive enough to have its own body of knowledge. This is why technology often alters decisions in the oil and gas supply chain line. This is the reason that the concept of the supply chain has to be reviewed in this paper in order to explain the reasons behind identifying the barriers to technology (Jacoby 2012). However, as the concept of the supply chain is broad, this research will look at the holistic overview of the supply chain in the oil and gas drilling sector from different levels and will not consider too many detailed segments of the supply chain.

2.1 Introduction to Supply Chain Management

Although technological solutions and supply chains have developed in recent years, there are only a few organisations utilising advanced supply chain strategies for their developments and operations (Cox et al. 2001). This is connected with organisational and process aspects rather than technological problems (Jaklic et al. 2003). A good example of this is the BP 2010 Deepwater Horizon disaster in the Gulf of Mexico. Organisational supply chain issues related to poor management seem to be the main reason behind the disaster, not technical or technological issues (Inkpen & Moffett 2011).

After providing an overview of supply chain management concepts, this chapter presents a literature review of the relevant concepts in reference to barriers to supply chain management in innovation and technology transfers. This chapter aims to identify the barriers to integration of supply chains. Furthermore, challenges of horizontal and vertical knowledge transfer and innovation in the supply chain of the drilling sector are targeted.

Through the literature review, a comprehensive analysis of the concept of the supply chain is provided which is used to address the issues of existing perceived barriers and determine the effect of the barriers to the systematic approach of the value chain and the development of the supply chain in innovation and technology transfer. The supply chain and procurement of the Australian onshore drilling industry are also investigated in depth.

2.2 Supply Chain Management (SCM)

The nature of the supply chain, as well as its practices, has changed dramatically over the years. Supply Chain Management (SCM) has become an imperative strategy for the purpose of reducing costs, minimising time and maximising the efficiency of the overall operation (Angeles 2005). In each organisation, the supply chain operation includes all functions involved in filling a customer demand (Chopra & Meindl 2007).

As shown in Figure 2.1, the supply chain of any industry is a worldwide network of suppliers, factories, warehouses, distribution centres and retailers through which raw materials are acquired, transformed and delivered to clients (Sherer 2005).

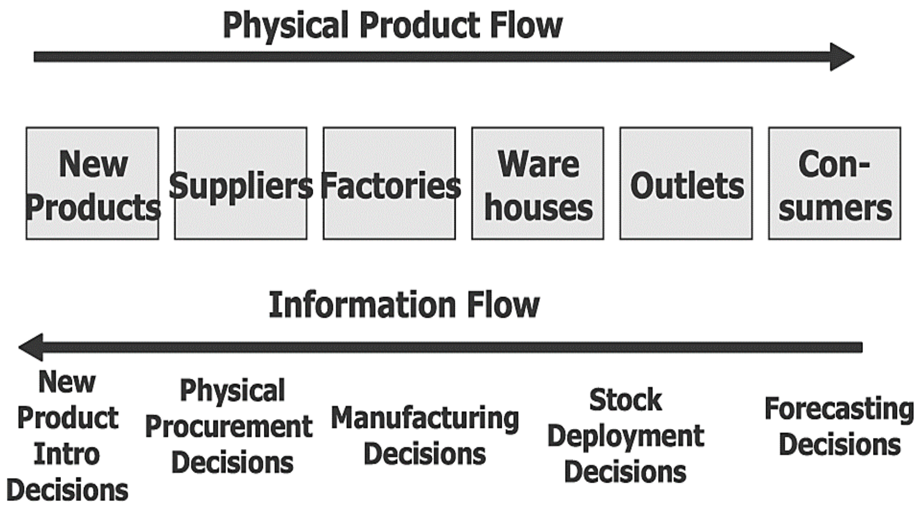


Figure 2.1: Supply Chain Management (Sherer 2005).

In order to optimise performance, supply chain functions must operate in a coordinated manner. Consequently, the supply chain management system must coordinate the revision of plans or schedules across supply chain functions (Fox, Chionglo & Barbuceanu 1993). In contrast, the supply chain of the oil and gas industry has a unique structure as it relies on the basic principles of supply chain management (Figure 2.2).

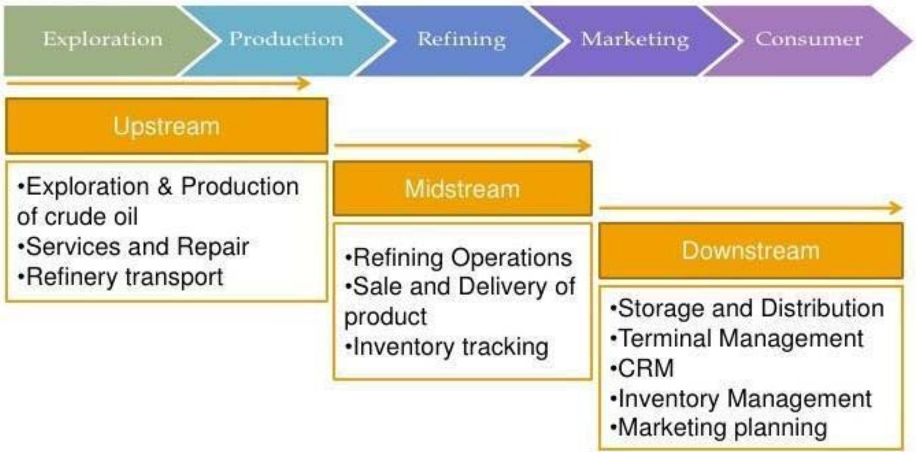


Figure 2.2: Oil and Gas Supply Chain Management (Gray 2014).

Effective supply chain management has become an emerging strategy for Australian companies and manufacturers in order to secure a competitive advantage and improve organisational performance in today's global market

(Plunkett Corporation Ltd 2010). To achieve this, Australian companies are required to implement effective supply chain concepts and characteristics that significantly and directly impact the overall process of productivity (Angeles 2005). Companies that have the capability to implement supply chain integration to lift their operational performance in response to industry forces have their innovative products in the market first (Yusuf et al. 2004).

As the supply chain interacts with all the sectors and activities that are processed in the business system, it is important to find an effective supply chain business model that suits the business type and industry type and can be implemented to improve the efficiency of the entire supply chain. Two popular models in supply chain management are: 1) process reference models of supply chain such as the Supply Chain Operations Reference model (SCOR model) and 2) collaboration initiatives such as Collaborative Planning, Forecasting and Replenishment (CPFR) (Fox et al. 1993).

Figures 2.3 and 2.4, which are provided by the American Petroleum Institute (API), illustrate the critical elements of the oil and gas industry supply chain. It is important to mention that although the supply chain of the oil and gas industry models can vary in the midstream and downstream, the upstream side of the oil and gas industry (stages: identifying, exploring, designing and construction, production) are the same as the below models indicate.[2]

[2] “Upstream", “midstream” and "downstream" are general terminologies used to refer to stages in the supply chain of the oil and gas industry.

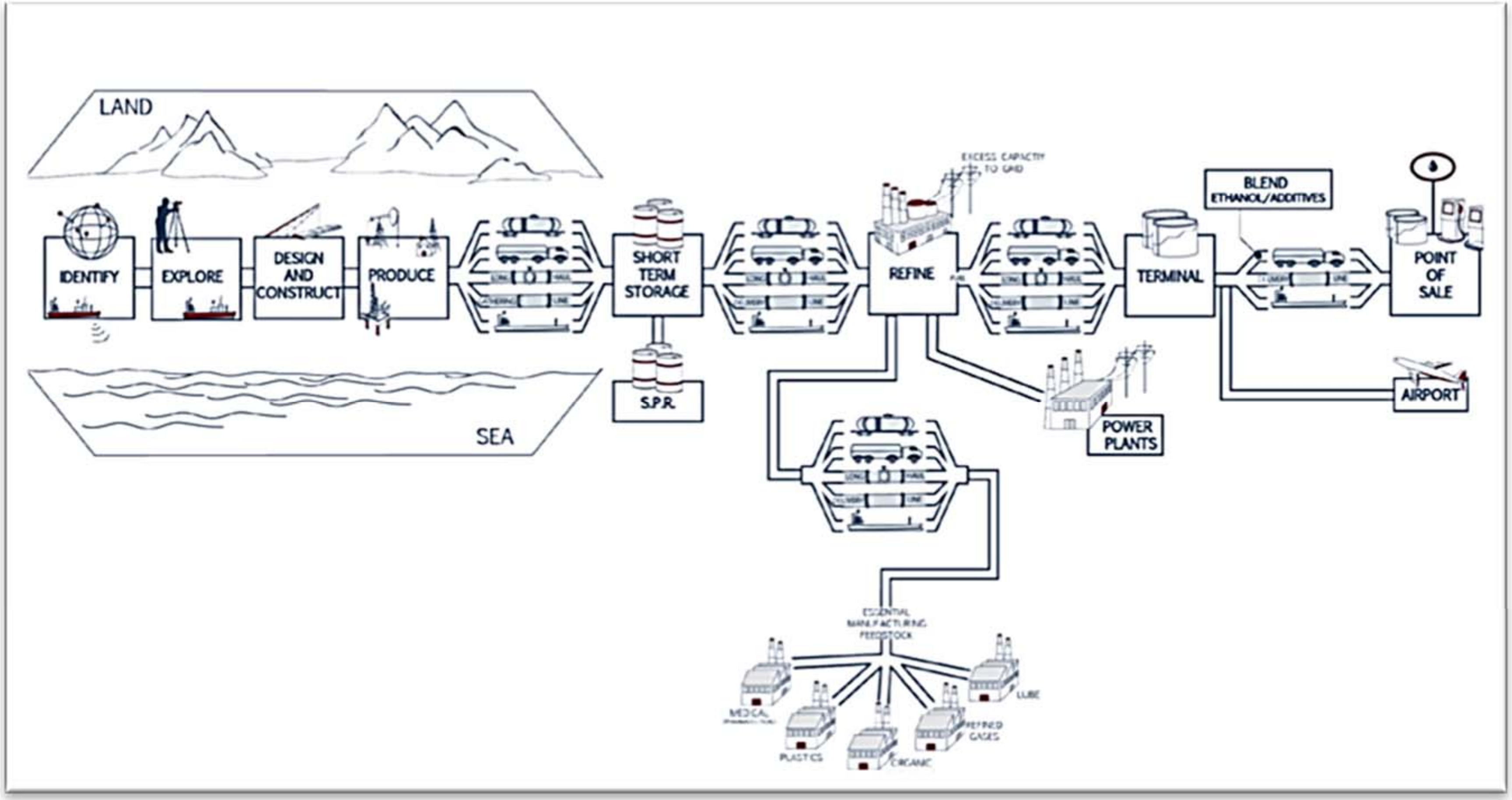


Figure 2.3: Critical elements of the oil supply chain (API 2015).

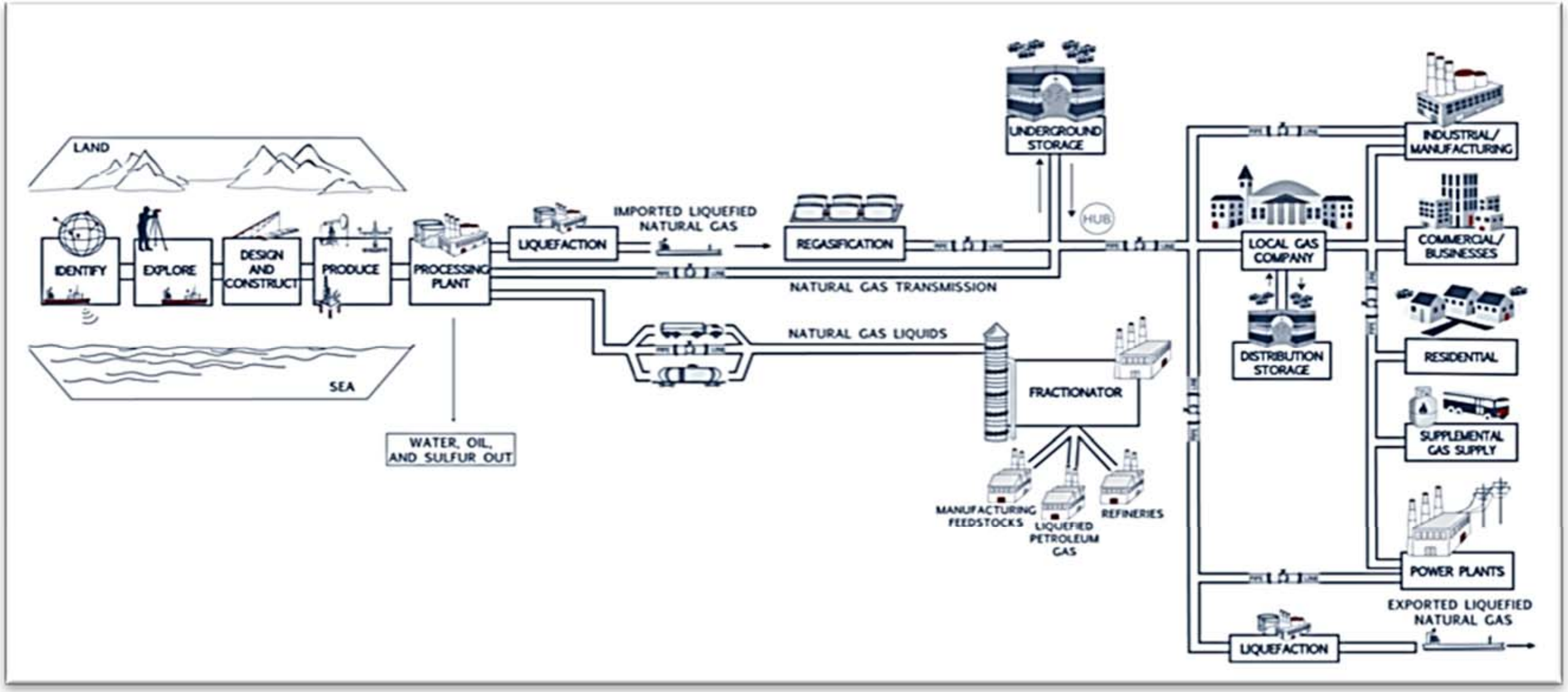


Figure 2.4: Critical elements of the gas supply chain (API 2015)

The goal of the next section is to explain the supply chain models while referring to the abovementioned supply chain structures.

2.3 Supply Chain Models

2.3.1 Supply Chain Operations Reference Model (SCOR model)

As illustrated in Figure 2.5, the Supply Chain Operations Reference model (SCOR) is a process reference model created for the purpose of effective communication between supply chain partners (Stephens 2001). This is an appropriate tool to evaluate the characteristics of communications within the Australian drilling sector. The Supply Chain Council (SCC) developed the model to improve the standard of Supply Chain Management (SCM) (Miller 2001). The application of the model is run under the integration of operational strategy, material, work and information flows and endorses the processes of each activity in the business operation as a whole (Jain & Anand 2001; Simchi-Levi & Kaminsky).

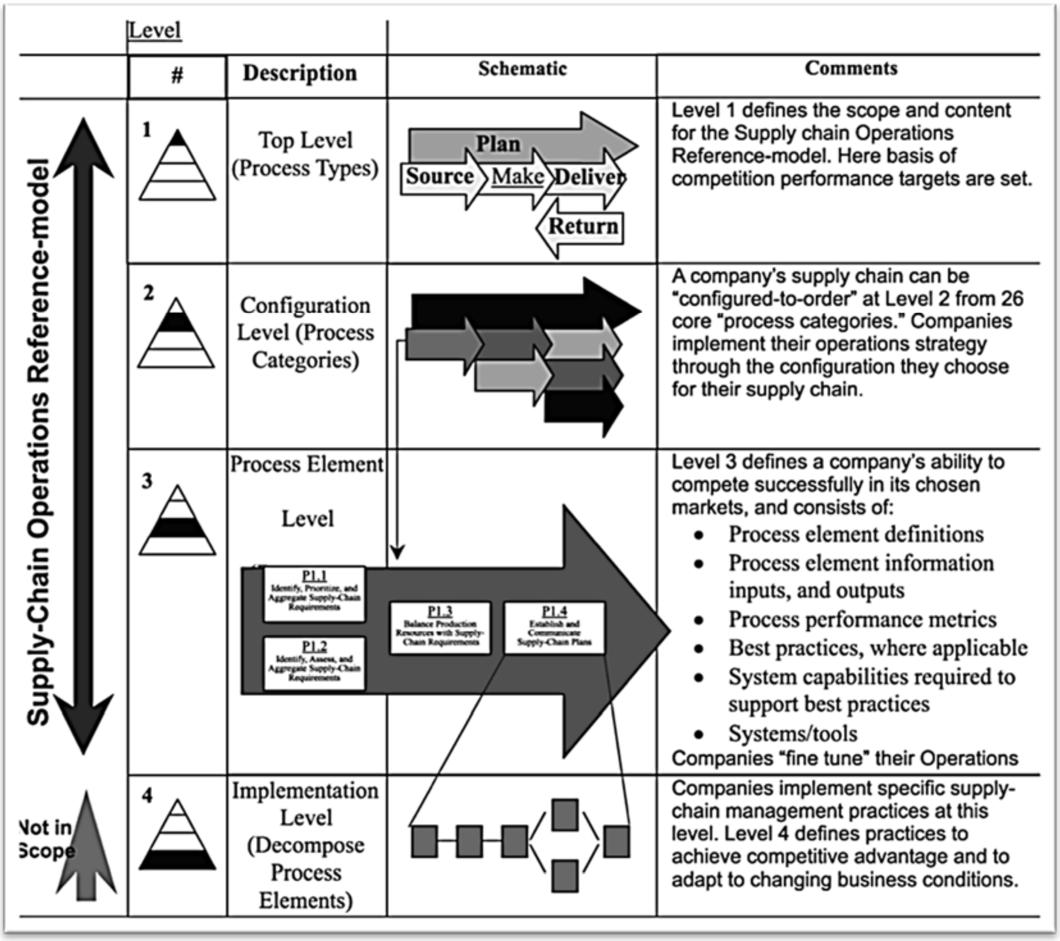


Figure 2.5: Supply Chain Operations Reference Model (Lockamy & McCormack 2004).

This model can be applied to create an advanced supply chain optimisation matrix to develop new techniques and functionality for analysing and determining solutions in trading operations and networks (Cachon 2004).

The SCOR model is utilised as the foundation of the relationship analysis within the organisation, as well as the relationship between the different levels of the Australian drilling industry supply chain. This analysis has developed a deep understanding of the knowledge transfer relationship between different levels of the drilling industry and at the company level.

Process reference models such as the SCOR model integrate the well-known concepts of business process reengineering, benchmarking and process measurement into a cross-functional business process (Miller 2001; Stephens

2001). The model is used to evaluate communications between different levels of the horizontally and vertically integrated sectors of oil and gas companies within the Australian drilling sector. Additionally, the SCOR model has been used to develop a similar model to illustrate information flow in the Australian oil and gas drilling industry.

It is important to mention that only the first stage of the SCOR model (top level - process types) has been used for the company level evaluation as further investigations at the other company levels is beyond the scope of this research. The extent of communication between different industry sections and the effect of the well-practised communication model on the innovation and technology transfer will be addressed in future chapters.

2.3.2 Collaborative Planning, Forecasting and Replenishment (CPFR)

Collaborative Planning, Forecasting and Replenishment (CPFR) is a framework for trading partners to collaboratively forecast client demand and to plan their future trading activities based on the demand. This enables trading partners to collaboratively manage the supply chain (Dolgui et al. 2010). CPFR is an appropriate tool to evaluate collaboration within the Australian drilling sector.

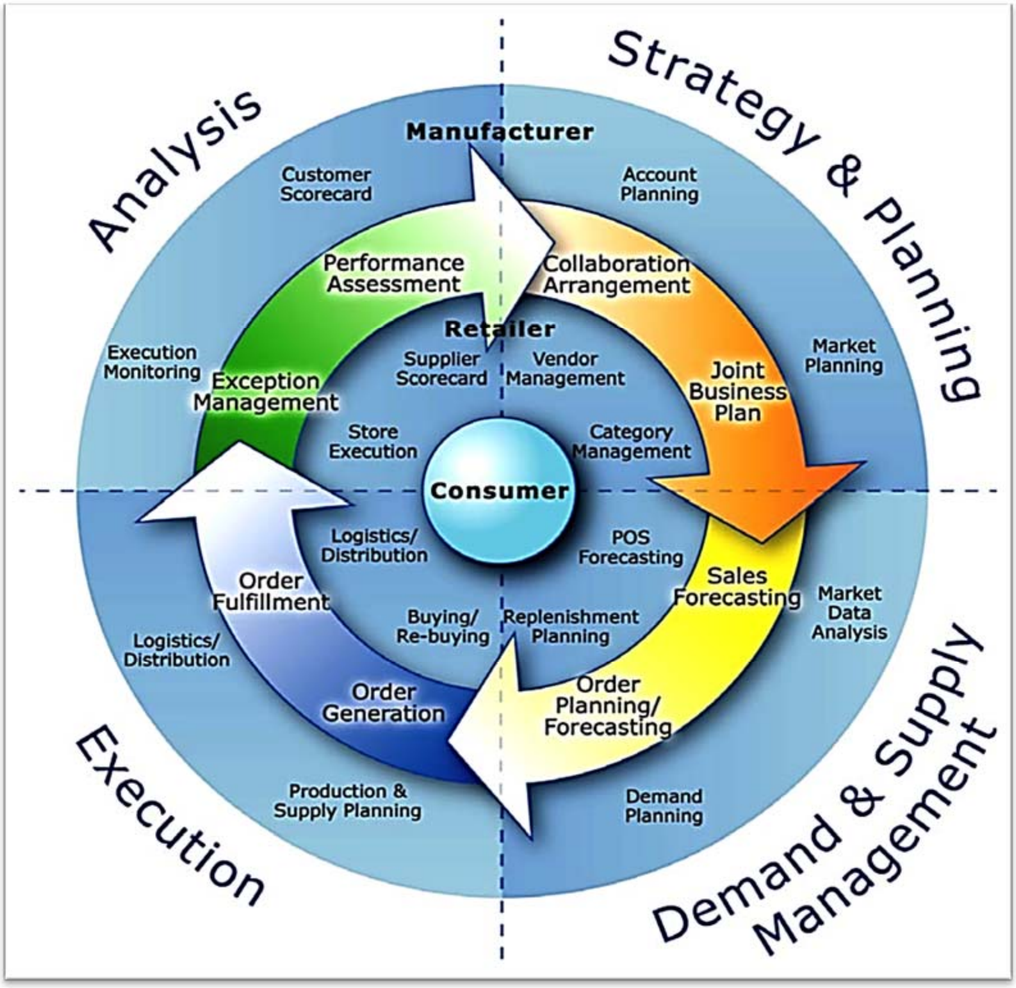


Figure 2.6: Steps in implementing the CPFR (Dolgui & Proth 2010).

As indicated in Figure 2.6, CPFR is a matrix which covers and formulates indices of the supply chain to provide an interconnected characterisation of the supply chain. CPFR also provides templates for supply chain partner collaborations. With internet-based CPFR, consumer behaviour is communicated to all levels within the value chain, making the interpretation of the change in traditional models transparent to all participants (Dolgui & Proth 2010).

CPFR is used to evaluate local and international collaborations between different sectors of the Australian drilling industry, as well as examining the effects of collaboration on innovation and technology transfer. The information obtained from utilising this model is used to develop the hypothesis on the level of local and international collaboration between the different levels of the Australian drilling sector. This raises the question of whether Australian drilling companies collaborate at the local level and whether there are any collaborations between the Australian drilling industry and the global drilling industry at the international level. In order to understand the abovementioned models and their applications in this research, the scopes and stages of the supply chain process are explained in Section 2.4. The hypothesis on the level of local and international collaboration between different levels of the Australian drilling sector and to what extent the collaboration is proceeding is also analysed. In order to understand the abovementioned models and their applications, the scopes and stages of the supply chain are explained.

2.4 Supply Chain Scopes and Stages

Supply chain management (SCM) can be defined as “the configuration, coordination and continuous improvement of a sequentially organised set of operations” (Chima 2007). The goal of supply chain management is to provide maximum customer service at the lowest cost possible (Chima 2007). Hence, the objective of every supply chain is to maximise the overall generated value (Chima 2007). The value (also known as supply chain surplus) that the supply chain generates is the difference between what the final product is worth to the customer and the costs the supply chain incurs in filling the client’s request (Chopra & Meindl 2007). The supply chain design, planning and operation decisions play a significant role in the success or failure of a firm (Chopra & Meindl 2007).

The prosperity of a supply chain is directly related to the strength of management schemes, which contain the flow of information, products and finances. The failure of a supply chain can be attributed to weaknesses in supply chain design and planning and particularly in the flow of information (Chopra & Meindl 2007). The information flow, supply chain design and planning can affect the entire value chain. To identify the issues and weaknesses in the supply chain of the Australian onshore drilling industry, all three mentioned factors are evaluated. The management scheme on a large scale for the drilling sector is an essential topic which will be discussed through the evolution of communication, collaboration and innovation budget.

All supply chain activities belong to one of three macro processes: Customer Relationship Management (CRM), Internal Supply Chain Management (ISCM) and Supplier Relationship Management (SRM). Integration of the three macro processes is crucial for successful supply chain management (Chopra & Meindl 2007). CRM, SRM and ISCM are discussed through analysing vertically and horizontally integrated strategies. This is the most appropriate model to evaluate the relationship between project owners as customers, drilling operators as providers and manufacturers and third-party contractors as suppliers. Although some may argue that drilling contractors can be considered as suppliers of services to project owner companies, this approach is chosen to simplify the model for research purposes. [3]

Advanced information and communication technologies can improve the synchronisation, coordination and harmonisation of supply chain design, planning and information flow. In addition, these advanced technologies can improve the integration within the supply chain management regardless of the complexity of oil and gas operations Consequently, the flow of information empowers all sectors to be involved in the supply chain management decision making (Chima 2007).

2.4.1 Supply Chain Decision Stages

Economic supply chain management is involved in many decisions based on the flow of information, products, and finances. Generally, in the oil and gas industry, supply chain management of high-technology operations and low-technology operations is performed separately. Due to differences in the quality of products and services as a result of the economy of scale and supply

[3] In future chapters, the different layers of supply chain and key elements are clearly explained.

chain surplus; capital-intensive operations and labour-intensive operations are also managed differently.

“A cycle view of the supply chain clearly defines the processes involved and the owners of each process. This view is very useful when considering operational decisions because it specifies the roles and responsibilities of each member of the supply chain and the desired outcome for each process” (Chopra & Meindl 2007).

This is why all decisions should align with enhancement in the supply chain surplus. These decisions fall into three phases based on their impact on the operations and the frequency of the events (Figure 2.7). Accordingly, each stage of decisions should observe uncertainty over the decision perspective (Chopra & Meindl 2007).

All three different phases including global competition and competitive strategy, constraints and barriers and local and global relations, etc, are investigated to identify any perceived barriers to the innovation and technology transfer within the supply chain of the drilling sector. Although innovation and technology transfer strategies will go beyond logistic boundaries and will merge into strategies and politics, it is necessary to discuss the three phases precisely in order to identify the barriers.

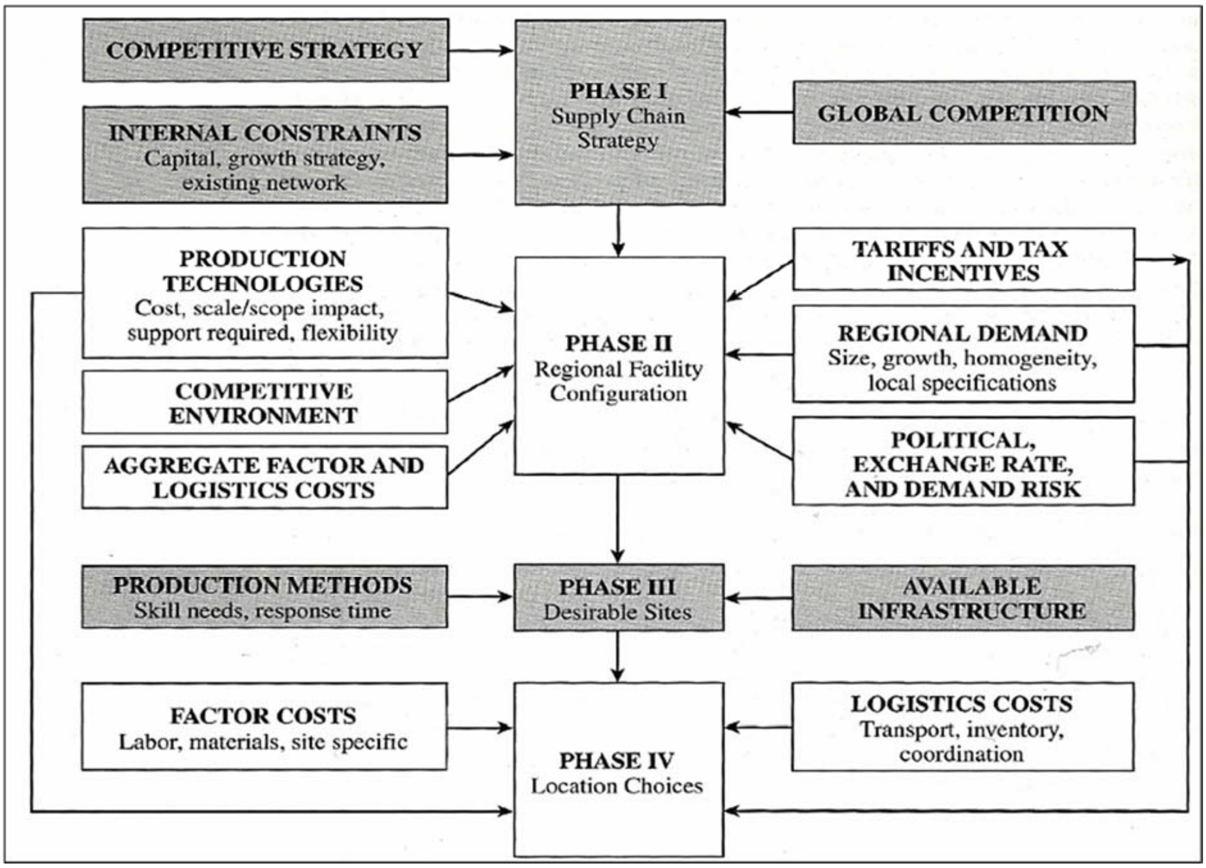


Figure 2.7: Decision-making stages
(Adapted from Chopra & Meindl 2007).

2.4.1.1 Supply Chain Design

The supply chain design stage is the long-term structural decision-making phase for a supply chain carried out over a few years. The structure of the chain's arrangement, source allocation and the other stages performance methods are planned during the supply chain design. Strategic designs at this stage consist of decisions made to either insource or outsource the supply chain function. Other decisions made at this stage include the location and production capacity and storage facilities, transportation and shipping methods and utilisation methods of information systems. The strategic aspirations and the supply chain surplus enhancement should be aligned in the supply chain design stage. Changes required at short notice can be costly, which consequently affects the supply chain surplus. Reviewing the supply chain decision-making stages is beyond the scope of this research. However, more details are provided in Chopra and Meindl (2007); Gibson, Mentzer and Cook (2005); Marien (2000).

2.4.1.2 Supply Chain Planning

Decisions made at the supply chain planning stage have a timeframe ranging from three months to one year. Hence, the supply chain's pattern determined at this strategic level is rigid and limits the planning that can be done. The aim of this specific pattern at this level is to increase the supply chain's surplus to the highest level possible through the strategies designed at the previous level. The aim of strategic decisions at this stage is to estimate the cost, supply demand, supply market options, contracting and subcontracting and inventory policies of the upcoming projected year. The elements which affect the decisions in this phase can be the uncertainty in demand, exchange rate fluctuation and the time frame in competitive advantage indices (Chopra & Meindl 2007). Supply chain planning will not be discussed further as it is beyond the scope of this research.

2.4.1.3 Supply Chain Operation

At the supply chain operational stage, there are no changes in supply chain arrangements, design or patterns. During this phase, sourcing, transportation methods, warehouse locations, information, inventory, pricing and schedules are confined and restricted. The plans in this stage are decided on an hourly, daily or weekly basis, hence the aim throughout the operation stage is to maximise the optimum routine and supply chain surplus (Chopra & Meindl 2007). It should be noted that the same principles apply for the supply chain of the oil and gas industry. Further discussions are provided on the operational side of the oil and gas supply chain in the following sections.

2.5 Supply Chain Enablers: Organisational Infrastructure, Capabilities and Technology

Many researchers have identified several supply chain management issues, practices and strategies that companies take into consideration when establishing and effectively running their supply chain (Chopra & Meindl 2007; Gardner 2001; Gibson, Mentzer & Cook 2005).

Chopra and Meindl (2007); Gibson, Mentzer and Cook (2005); and Marien (2000) laid out the four key enablers that are central to SCM effectiveness. These supply chain enablers were based on a survey of supply chain industry professionals. Marien (2000) stated, “Companies that recognise the scope of the supply chain management enablers and the resulting barriers that can form in their absence position themselves for business success.” Analysing the information derived from literature searches as well as the studies conducted by Marien (2000) and Chopra and Meindl (2007) have persuaded the researchers to investigate the supply chain structure of the oil and gas industry from an organisational, industrial and technological point of view. The same pattern is chosen in investigating and identifying the perceived barriers to innovation and technology transfer in the drilling industry.

Furthermore, it is important to know how business units and functional areas are organised as it is critical to understand the specific organisational characteristics that are considered essential to successful SCM implementation (Marien 2000). This is where the operational stage becomes a vital and unchangeable factor. At the operational stage, there will be no changes in supply chain arrangement, design or patterns. During this phase, sourcing, transportation methods, the location of warehouses, information, inventory, pricing and schedules are confined and restricted (Chopra & Meindl 2007).

At the end, it is important to focus on the concept of technology in the supply chain. When technology is mentioned in the context of implementing SCM initiatives, information technology is what comes to mind. However, at this point, technology goes beyond information. From the study conducted by Marien (2000), a number of supply chain professionals identified that it is important to understand how technology affects a company's operational and strategic supply chain processes. In addition to information technology, the concept of technology encompasses the 'physical' materials such as management technologies for material design or operations. It was pointed out in Marien (2000) that technology was related to how products were manufactured, handled and transferred throughout the supply chain.

As this research focuses on the concept of technology transfer in the supply chain process, the issue of technology will not be discussed in more detail. The technology in the supply chain and a specific technology in the drilling industry is irrelevant and the focus will remain on the transfer of technology and the concept of technological and non-technological innovations.

2.5.1 Strategic Integration With Supply Chain Members

Alliances or integration are critical to supply chain efficiency. If organisations are to achieve the full benefits of SCM, they must integrate and streamline the flows of products between supply chain partners. This entails the development of flow through transportation systems and intermediate assembly and distribution facilities to increase inventory velocity and meet differentiated customer needs (Plunkett Corporation Ltd 2010).

In order to gain a better understanding of the Australian value chain on a global scale, Figure 2.8 is used. The figure is adapted from the 2014 Australian Innovation System Report to investigate the integration, collaboration and level of participation of Australian industries in the global market.

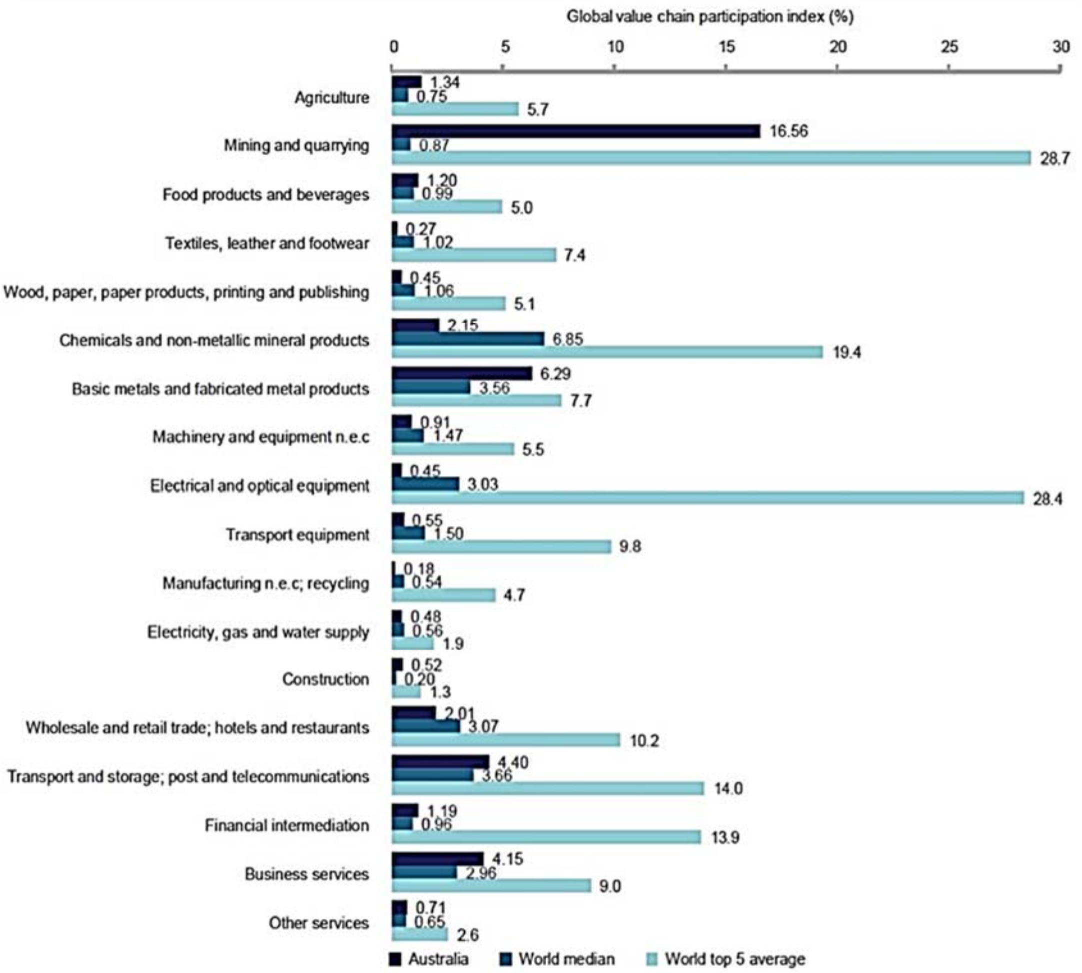


Figure 2.8: Global value chains indicators (Hendrickson et al. 2014)

As illustrated, the mining industry, including the drilling industry; has 16.56% participation in the global value chain and Australia is positioned well above the world median. The question arises that since the mining industry's value chain involvement is at such a high rate, why do other supporting industries such as manufacturing, machinery and equipment have such low rates in the global value chain indicators? Also, to what extent can the supporting industries' performance affect the drilling industry?

The oil and gas industry has unique and complex supply chain challenges which often involve various methods and comprise everything from supplies for oil rigs to the transportation of exceedingly heavy equipment. The complexity of the oil and gas supply chain is also highly related to the operational style: whether it is the traditional operational style or exploratory style. Each form of operation involves a different supply chain strategy (Brown 2015).

John Love, Senior Vice President and Senior Architect for Raleigh mentions that, “The exploration and extraction supply chain is different than the supply chain from a well site to a refinery, especially in the people and processes involved” (Supply Chain Management, Logistics and Supply Chain Segmentation, 2014). Consequently, this is the benchmark for the supply chain, where the drilling industry’s supply chain takes a different path. Subsequently, manufacturers often develop substantial value from supply chain providers that can redesign the traditional operations’ supply chain processes (Brown 2015). The supply chain of the oil and gas industry with a specific focus on the drilling sector will be discussed in the following section.

2.6 Supply Chain Management in the Oil and Gas Industry

Concerns about oil reserves have been raised recently. According to BP’s statistical review of the world’s energy, the total world’s verified oil reserves were down to 1687.9 billion barrels at the end of 2013; just enough to meet 53.3 years of the world’s demands (BP Statistical Review 2014). This means that for the next 53 years, challenges in the supply chain of oil and gas will be identified and efforts will be put in place to overcome them.

Since the end products of the drilling companies will all be the same in the competitive market, there will be no option to modify the end product. Hence, the main challenge for oil and gas firms to maintain competition will be limited to the cost of production and time of delivery. This goal will only be achievable through an efficient supply chain management system (British Petroleum 2013). In order to investigate the possibilities of higher efficiencies, technology transfer in this section of the industry will be investigated.

2.6.1 Supply Chain of the Drilling Sector

The oil and gas industry, which includes the drilling sector, is experiencing the effects of challenging economic periods. A decrease in commercial and non-commercial demand has led to a downturn in exploration, production and transport activities. In addition, it is expected to generate lower growth rates from emerging economies. In this unstable global economy, controlling costs will remain a challenge for the oil and gas drilling sector, especially in the quick-fix. One way to solve this inefficiency is to apply advanced technology functions to support a diverse, dynamic and sustainable supply chain.

The drilling companies need to integrate models to provide capacity and support each stage of activity as a technique to make it flexible and more influential. In other words, modelling and integrating appropriate applications effectively is a critical phase in building Supply Chain Management. Lee (2002, p. 107) identified that due to the continuing trends of expanding product variety, increasing outsourcing, business globalisation and improvements in engineering and information technology, effectively managing supply chain operations has become challenging. Engineering technologies can be linked with certain areas of supply chain management and operation management that are used within certain supply chain operations.

For instance, it can be hypothesised that a firm performing well in logistics management, operations management and that has appropriate engineering technologies should have a competitive advantage over a firm that performs poorly in these areas (Lee 2002). Therefore, the concept of technology in supply chain management needs to be reviewed. The perception of engineering technology will be reviewed as a general concept; as a specific technology at this stage it is irrelevant. This research study attempts to determine how companies in the Australian drilling industry implement and utilise innovation and technologies in their operations' supply chain management.

Australia and particularly Queensland are on the border of having a world-class Liquefied Natural Gas (LNG) export industry. Major LNG processing plants have been proposed since 2010 for Gladstone in Queensland to transfer Coal Seam Gas (CSG) from the Surat Basin's lucrative fields (Haworth 2010). CSG has powered Queensland households for more than fifteen years. Currently, Queensland is providing 90% of Australia's domestic gas supply (Department of Natural Resources and Mines 2014).

As shown in Figure 2.9, a large portion of drilling in Australia, particularly in Queensland, is CSG drilling. As if the oil and gas supply chain is not complex enough, drilling for CSG is the start of a new series of challenges for the supply chain. These challenges are due to factors such as the shortage of mainstream drilling and the decline of unconventional oil wells over more traditional wells. This means that a higher material supply is required to maintain the unconventional wells. Additionally, traditional oil wells require smaller size fields in comparison to unconventional wells (Banker 2014a).

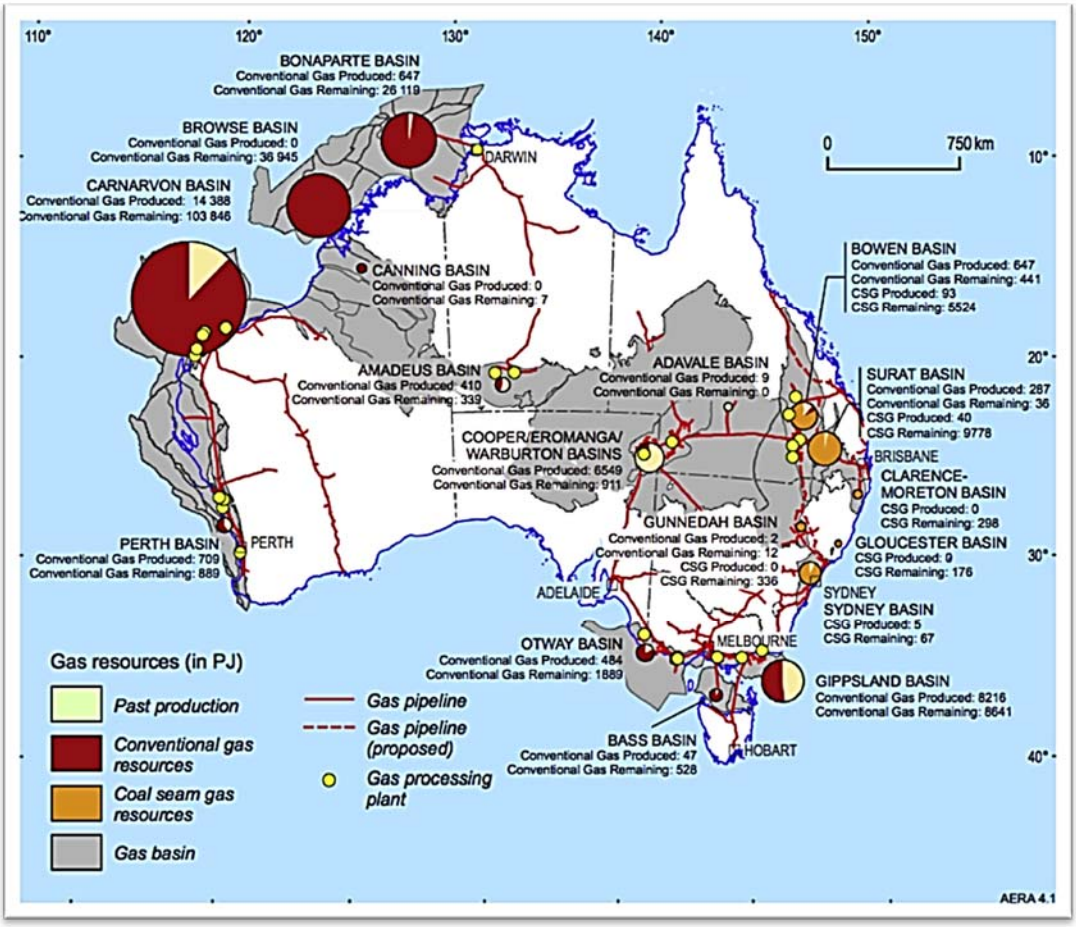


Figure 2.9: Gas production activities of Australia (SBS 2013)

Generally, we can divide the supply chain of the unconventional fields into four categories. The supply chain related to the infrastructure includes rig manufacturing to support more frequent operations for the frequently declining fields. The second category entails the supporting infrastructure used to separate gas from the other components such as water and sand at the wellhead. The third category includes the supply of materials such as chemicals to support the drilling operations in larger quantities. The final category is the supply chain associated with infrastructures used to remove and transport the products of the drilling operation (Banker 2014b).

The abovementioned explanations confirm that the upstream section of the oil and gas industry has unique supply chain activities, which gives the drilling sector unique and uncommon routines and methods. In this research, the supply chain of drilling oil, natural gas or CSG is approached from a general point of view, with disregard to small technical differences. In the next section, the characteristics and distinctive aspects of the oil and gas supply chain and the concept of innovation and technology transfer are discussed.

2.7 Technology Transfer and Innovation in the Oil and Gas Supply Chain

Studying and analysing the oil and gas industry's supply chain can be complex and sometimes unclear. A supply chain strategy and policy for this industry comprises the improvement of boundaries and parameters that control the interactions between the clients and contractors. This improvement occurs when two oil and gas companies unite to either purchase/provide products or services or both. This is an advantage because in the oil and gas industry one company's production is another company's input. For example, the output of drilling is the input to refineries. The oil and gas industry is an exceptional environment for the development of what is known as vertical integration (Chima 2007).

However, regardless of how good the current supply chain of the oil and gas is and how well the policies, strategies and technologies are placed, there remains potential for improvement. This is important as a lack of improvement for any firm within the industry can lead to a loss of competitive advantage (Chima 2007). Improvement requires innovation, particularly in the operational environment. Operational innovation can simply be solving existing problems using new procedures (Chima 2007). Over the years, oil and gas companies, including the drilling sector, developed through mergers, acquisitions and business divergence. Growth, development and financial improvement are achieved through innovation in the operation sector. Before this is discussed further, the concept of technology transfer and innovation will be reviewed in the following section to determine the extent of these concepts in the industry.

2.7.1 The Concept of Technology Transfer

Anyone dealing with the concept of technology transfer understands the complexity and difficulty of defining and placing a boundary on the perception of “technology”. Moreover, streamlining the technology transfer process is practically impossible and gauging the influence of the transferred technology has been a challenge for researchers (Bozeman 2000). The reason is that generally the technology transfer is vastly meshed into the texture of all dimensions of the organisation in a way that makes it hard to separate it from other organisation sectors. The impact of the value and effect of technology transfer on organisational policies, operational policies, knowledge-based economy and innovation management of the value chain will be reviewed in this section. Particular emphasis will be placed on the barriers to innovation and technology transfer management issues from the perspective of a knowledge-based economy.

The concept of technology transfer has been widely used to define and analyse an extensive series of technology issues. Roessner (2000) defines technology transfer as, “the formal and informal movement of know-how, skills, technical knowledge or technology from one organisational setting to another”. As expected, the traditional technology transfer process imposes a high demand for informational, financial and human resources and hence faces inadequate economic incentives and other services necessary to convert new ideas into innovations. To overcome the issues with the traditional technology transfer process, it is imperative to modernise this traditional process. The necessity to improve, grow and expand the knowledge-based economy towards a more efficient system, which lacks transparency amongst operation and knowledge transfer, and lacks focus on vertical and horizontal organisational knowledge transfer, are profound invitations for the remodelling and reinterpretation of the basics of technology transfer. It is clear that this perception affects and contributes to the area of innovation management as well (Fernand & Patrick 2001).

This new focus on innovation and technologies requires the reassessment of the perceived barriers to technology transfer and innovation management; specifically recognition and examination of the different transfer contexts. Some aspects of the current practices of technology transfer, innovation management and the knowledge-based economy will be covered in the following section in order to address the issues of the perceived barriers more accurately.

2.7.2 Introduction to Innovation

"*One conclusion is that the strategic knowledge necessary for innovation not only concerns technology. It is rather about business intelligence, funding, marketing and other non-technical areas. Moreover, the production and development of frontline knowledge and research is not the sole province of universities. In many areas, companies are far ahead of universities. Both conclusions differ from the assumptions in mainstream innovation literature*" (Frankelius 2009).

During a detailed survey of innovation, Frankelius (2009) identified that there is a common assumption suggesting that the high-technology strategic knowledge for innovation is about technology. Furthermore, when referring to research and development for production or commercialisation, he found that all previous research studies focussed on technology rather than economics, marketing, sociology, business administration or customer psychology. Frankelius (2009) believes that technology transfer and innovation does not need to be specifically about technology. The best example to support this is Columbia Accident Investigation Board's (CAIB) statement about NASA's Challenger shuttle tragedy in 1986. CAIB announced that the reasons behind the Challenger shuttle incident were caused by NASA's poor organisational culture and decision-making processes rather than technological issues (Admiral Harold Gehman 2003). Therefore, organisational culture and decision-making processes are as important as innovation technologies in any project and non-technological factors need to be treated as being as vital as technological factors in the process of research and development.

Having this in mind, we will discuss the culture of innovation in Australia in the next section to see how Australia defines innovation and where Australia stands in terms of innovation on a global scale in order to identify the barriers to innovation in Australia.

2.8 Overview of Australian Oil and Gas Industry

Australia is a member of the Organisation for Economic Co-operation and Development (OECD), which promotes policies to improve the economic and social well-being of people of the world. Australia is one of the three hydrocarbon exporting members of the OECD. This is also one of the reasons that the OECD is being referenced as an index to evaluate the Australian innovation system. A brief examination of the Australian hydrocarbon sector, which is related to drilling, indicates that Australia is the largest exporter of coal in the world as well having reservoirs of oil, CSG and natural gas (Australian Department of Industry 2015)

Although most Australian-discovered oil and gas reservoirs are offshore, for the purpose of this paper we focus on the onshore sector only. Australia has been mainly focusing on offshore oil explorations and has an untouched wealth of oil reservoirs onshore in Western Australia, the Northern Territory, Victoria, South Australia and Queensland for future growth. Transferring the latest technologies and innovation and possibly reducing barriers will improve the future of oil and gas exploration in Australia (APPEA 2016).

Australia has one of the largest natural gas reserves in the Asia-Pacific region. Coal Seam Gas (CSG) reserves are only in New South Wales and Queensland and are an important domestic energy source. Liquid Natural Gas (LNG) is the fastest growing sector for the Australian energy sector. Australia is the world’s fifth-largest LNG exporter after Japan, China, Taiwan, South Korea and India (Australian Department of Industry 2015)

2.8.1 A Lesson From the Norwegians

Those in the oil and gas industry acknowledge the vital role of technology and innovation in the North Sea and the Norwegian oil and gas industry. Norway has been the world’s third-largest natural gas exporter, having significant gas reserves in the North Sea (International Energy Agency 2016). One of the interesting examples of the role of knowledge transfer in technological innovation goes back to the Norwegian discovery of oil 47 years ago. In 1969, oil was discovered in the Norwegian territory in the North Sea and, as a result of collaboration frameworks, Norway has one of the most innovative technology platforms for their oil and gas sector.

The combination of competition and collaboration as well as the proper support for R&D with the tax regime and the support of government through the Norwegian Resource Council have created a sustainable and firm foundation for the Norwegian oil and gas industry. Measuring innovation is almost impossible, but how new technologies are implemented and utilised is measurable through common methods such as referring to the number of patents (Hatakenaka et al. 2011).

There might be some arguments about the relevance of the Norwegian oil and gas industry to the Australian oil and gas industry. We have used Norway as an example of a country which has successfully put into place a systematic approach to technology transfer and innovation.

2.9 Innovation in Australia

The Australian Bureau of Statistics (ABS) defines innovation as: “The development or introduction of new or significantly improved goods, services, processes or methods”. According to this definition, the bar is not set too high for any company to be considered innovative in Australia (Australian Bureau of Statistics 2014). Although the definition provided by the ABS seems to be very general, less than half of Australian businesses are involved in innovative activities as illustrated in Figure 2.10. Specifically in the mining industry (including the drilling sector), only 42% of companies have been involved in any sort of innovation activities.

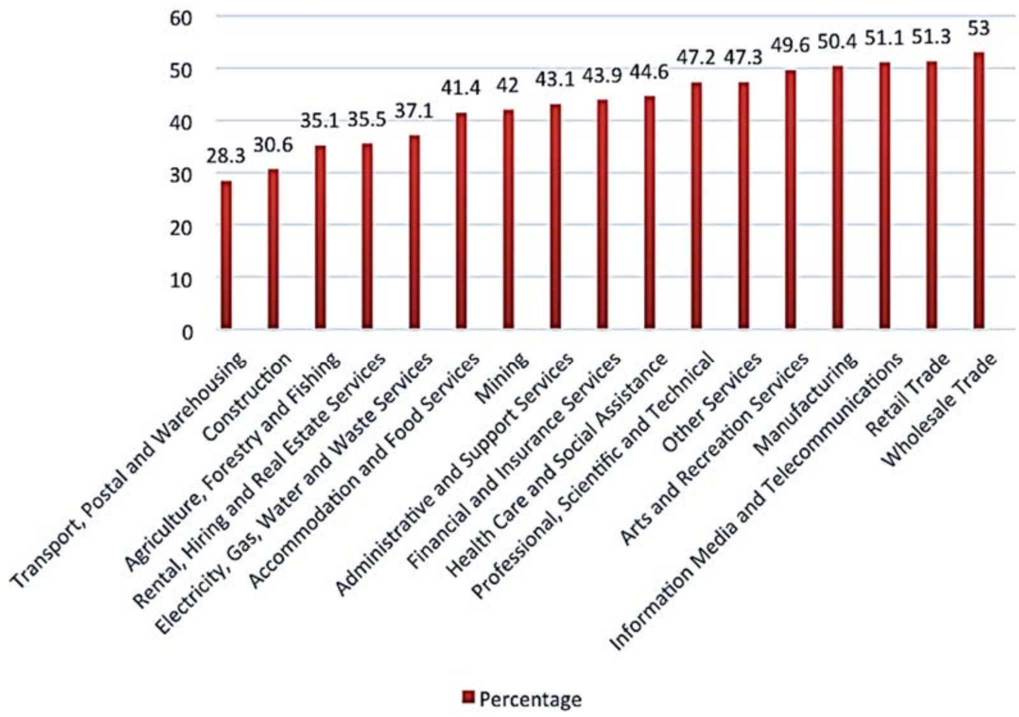


Figure 2.10: Innovation in Australian Business (Australian Bureau of Statistics 2014).

This means that the local trend of innovation in Australia is not strong enough and the use of innovation and technology transfer by local industries in Australia is also poor. Similarly, Australia does not perform well in the world of innovation according to the Global Innovation Index. As shown in Figure 2.11, Australia is ranked nineteenth on the global scale and it is located at the bottom of the list of the top twenty countries (Dutta & Lanvin 2013). This scale shows that amongst the top twenty countries, Australia is not doing very well.

There is a significant factor in addressing the current issues in the transfer of technology to and from Australia.

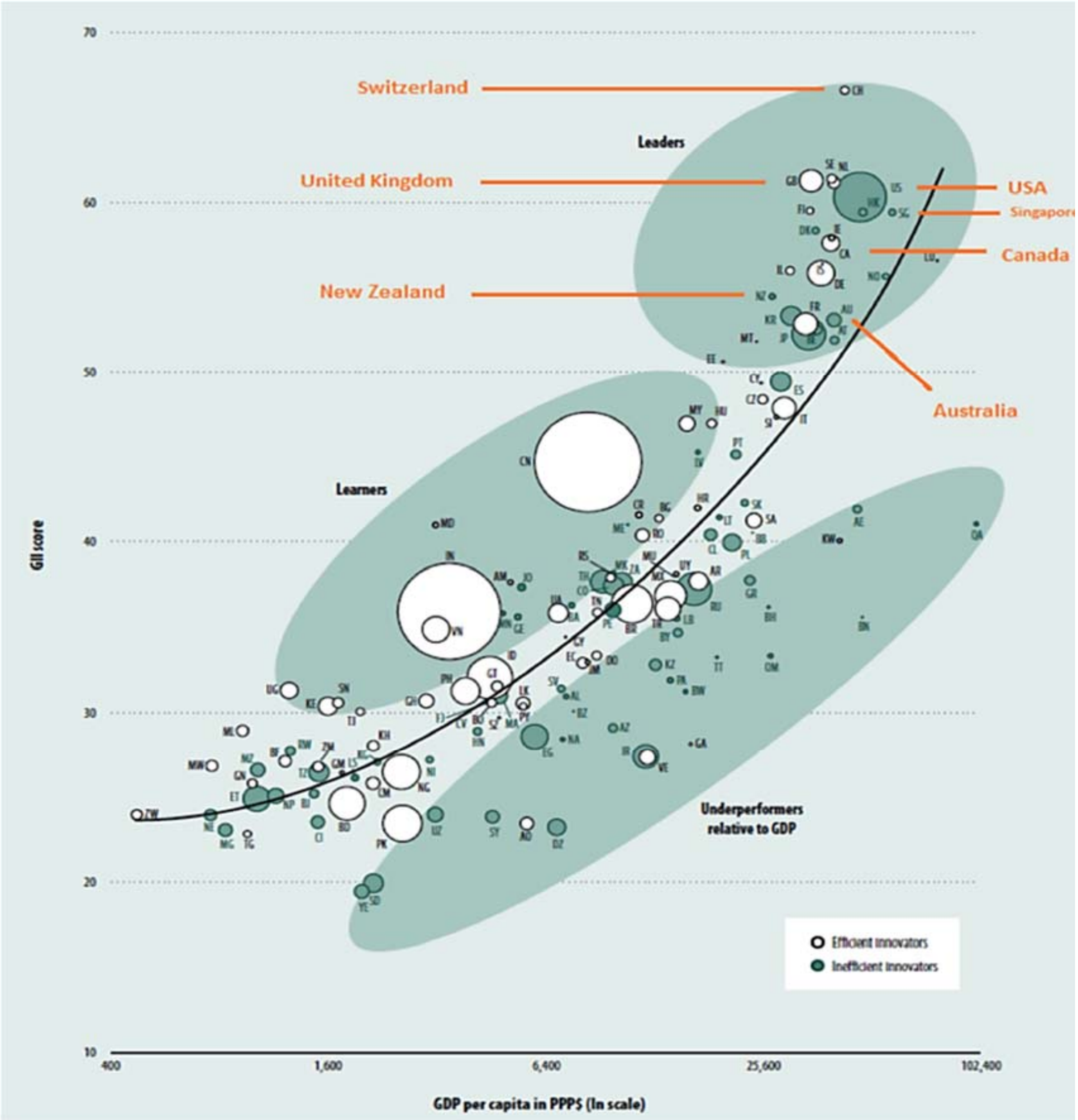


Figure 2.11: Global Innovation Index scores and GDP per capita (Dutta & Lanvin 2013).

When assessing the possible barriers to technology transfer, it seems that unclear government innovation policy measurements and lack of industry innovation trends are the major barriers (Hendrickson et al. 2014). The low rate of innovation and the geographic location of Australia also contributes to the absence of international technology and innovation in the Australian market. This paper covers an in-depth discussion about innovation in Australia and the perceived barriers to innovation and technology transfer in the drilling industry in Section 2.7.1.1. The following section will discuss the concept of technology transfer amongst the global oil and gas drilling contractors, as well as providing details on the relationship between the technology owners and the other partners of the value chain, which dictates the transfer of innovation and technology policies.

2.9.1 The Global Oil and Gas Industry's Strategy: the Relationship Between the Technology Owners and Project Owners

Generally, discovering and producing crude oil and natural gas are the fundamental activities in the upstream value chain. Access, leasing and exploration activities are the preliminary stages in the value chain. If an oil and gas company does not obtain a new reserve, there will be no new production opportunities. Finding new reserves is not limited to technology and the cost of seismic analysis and drilling; it also entails the laws, regulations, leases, auctions and permits. It is about establishing and managing partnerships, developing innovative new technologies to explore reservoirs and negotiating convoluted geopolitics (Inkpen & Moffett 2011).

Technology owners and project owners have always coexisted in the highly complicated and dynamic oil and gas industry. National Oil Companies (NOCs) are the project owners and they manage and control 90% of the global reserves (Economist 2006). Generally, NOCs can be divided into three groups. The first group includes NOCs that have limited skills in exploration, development and production. They normally rely on tax collection and royalty fees. An example is the Brunei National Petroleum Company. The second group includes NOCs that conduct the upstream activities within their borders, such as Qatargas. The third group covers the NOCs that take their skills outside their geographical home borders, such as what Petrobras (Brazil) and Petronas (Malaysia) do in the global oil and gas industry (Inkpen & Moffett 2011). Consequently, the conceptual structure of the project owner's approach dictates the relationship and the flow of technology and innovation policies.

On the other hand, International Oil Companies (IOCs) are the technology owners. As the NOCs are determined to gain more experience and knowledge in industrial science, they often purchase or rent technical knowledge from the IOCs. This means that when the technology owner company sells or lets their technology to the NOC, the IOC turns into a service contractor and loses the competitive advantages (Inkpen & Moffett 2011). In 1970, IOCs (BP, Esso, Gulf Oil, Mobil, Royal Dutch Shell, SoCal and Texaco) collectively owned 85% of the world’s oil reserves. Today, they own less than 10% (Economist 2013). To guarantee their involvement in major developments, IOCs offer a wide range of expertise. The NOCs’ reliance on the IOCs for technology and expertise dictates the fiscal relationship between the technology owner and the project owner. This means that oil and gas companies hold the management and technological knowledge necessary for the technological evolution, but they simply will not allow the transfer of knowledge (Inkpen & Moffett 2011).

The purpose of most global models and the relevant academic assessments regarding innovation and technology transfer is to create or increase efficiencies in the current system and to effectively and efficiently inject technologies and apply innovations in the industries. This is not solely about how to use technology in a technical way, but is also related to the IOCs and the countries internal policies and external political relationships.

Analysing the innovation and technology transfer of leading countries shows that the focus is not merely about being the champion of the technology competition, but it is rather about being the deployer, manufacturer and exporter of the next big innovation in technical and non-technical ways. The Organisation for Economic Co-operation and Development (OECD) declares that up to the year 2060 knowledge-based capital and innovation will be the way to overcome the threat of a new era such as the slowdown in economic growth, ageing population, etc. (OECD 2014). Mr Barack Obama, the then President of the most innovative country (Global Innovation Index 2013), stated, “None of us can predict with certainty what the next big industry will be or where the new jobs will come from. Thirty years ago, we couldn’t know that something called the Internet would lead to an economic revolution. What we can do -- what America does better than anyone else -- is spark the creativity and imagination of our people“ (White House 2011).

In order to identify the perceived barriers to technology transfer and innovation in the Australian drilling industry’s supply chain, this section has been divided into three categories: 1) the government level, which includes global competitiveness, 2) the industry level, including the drilling sector and 3) the company level. Supply chain models such as the Collaborative Planning, Forecasting and Replenishment, Supply Chain Operations Reference Model, etc, are used as platforms to examine the relationships within and between all three categories. Please note that the industry level analysis is covered in the global level and the company level discussions and findings.

Qualitative and quantitative data collection methods have been used to examine the relationships within company departments and between firms, industries, governments and research centres. In addition, international indices have been utilised to compare Australia’s current innovation situation, technology export and innovation culture with those of leading countries.

Before investigating the relationship in the supply chain of the Australian drilling industry, gaining an understanding of the innovation and technology transfer concept, the position of Australia in the global index and the reason behind the ranking is essential. In this section of the thesis, the OECD facts and figures have been utilised and referenced for most empirical evidence as well as other well-recognised sources. “The OECD is a unique international organisation which sets the standards and defines best practices in almost every field of economic and social policy” (OECD 2015).

2.9.1.1 Innovation Strategies and Technology Transfer in Australia - Government Level

In this section, the critical elements for innovation in the supply chain at the government and international levels will be addressed. Obviously, a strong integrated government structure and policy is essential to support the national innovation system. This hypothesis questions whether the government is providing appropriate and strategic supports to Australian industries and especially the drilling sector, in what forms these supports are provided and at what areas and faculties they are targeted. Universities and quality research institutions play a vital role in educating and carrying researchers forward and towards practical and operational innovations.

These dynamics, whether being practised at firms, organisations, universities or research institutions, need government support at all levels. This requires support, not only in the research and development sectors, but also requires governmental support to implement a system and to carry the results towards a wide-scale application (Blaustein 2014). The International Innovation Index guide of 2014 is used to rank Australia on the global scale. This guide is an index prepared by several organisations and valid institutions such as The Boston Consulting Group (BCG), the National Association of Manufacturers (NAM) and The Manufacturing Institute (MI) and announced by Bloomberg. Australia was ranked thirteenth in 2014 (Bloomberg 2014).

The 2014 Australian Innovation System Report indicates that since 2006, all types of innovation collaborations in Australia remained at the bottom of the OECD index. The same source indicates that only 6.1% of innovative companies in Australia have been collaborating on a global level. Figure 2.12 indicates that the involvement of Australian firms in international collaborations has a direct relationship to the size of the firm and the sector of the industry (Hendrickson et al. 2014). The reasons behind the factors affecting the collaborations will be explored later on in this chapter.

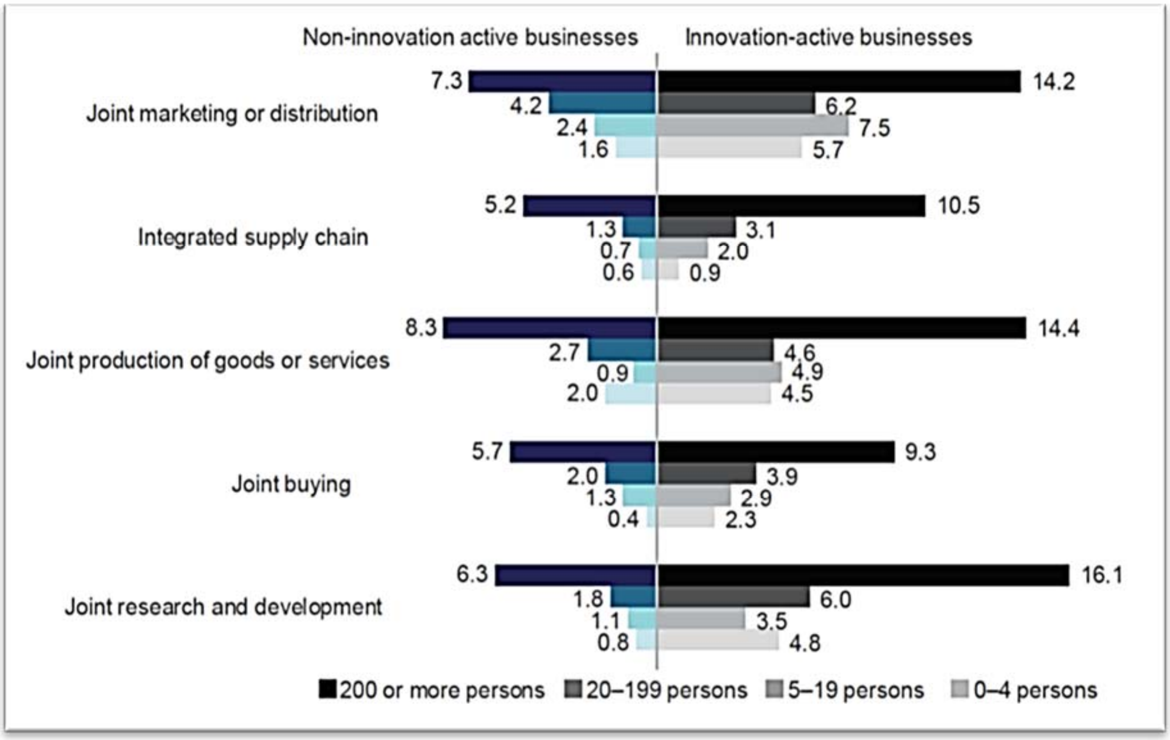


Figure 2.12: Collaborative arrangements by innovation status and employment size 2012-13 (Hendrickson et al. 2014)4

2.9.1.1.1 Australia's Collaboration on Innovation and the Global Innovation Engagement

"Innovation distinguishes between a leader and a follower"

-Steve Jobs (Woo 2013).

The 2014 Australian Innovation System Report, with reference to the Collaboration and Innovation Novelty paper of the Department of Industry, Innovation and Science, explains that small businesses in Australia are less likely to produce any "New to the World" innovations, in comparison to medium and large-sized businesses (Department of Industry, Tourism and Resources 2006). It is also mentioned that cooperation between research centres and industries is also quite low. Above and beyond these, the total number of research projects undertaken by small and medium-size enterprises in

[4] Source: ABS (2013) Selected Characteristics of Australian Business, 2011–12, cat. no. 8167.0, ABS, Canberra.

Australian industries ranked twenty-ninth out of thirty OECD members (Hendrickson et al. 2014). This shows a lack of motivation and a poor innovative culture in the Australian industry sectors, with limited collaboration initiatives that can contribute to the global supply chain. Australia's education system contains remarkable university research, which can be used to uplift the industry. According to OECD standards, Australia's quality research is ranked quite highly globally. As a result, a better linkage between research centres and industry sectors can improve the innovation index of Australian industries (Hendrickson et al. 2014).

There is also an organisational relationship between globalisation, exporting and innovation (Bell et al. 2014). Australian firms show poor collaboration at the global level and a very strong performance at the domestic level- Australia at 18.1% is ranked at ninth above the OECD median level, behind the top five countries (OECD Development 2013). This is a clear indication of the lack of motivation by Australian industry sectors to be involved in global innovation activities. Another consequence of this matter is the low level of trade for Australian innovation (OECD Development 2013). Figure 2.13 indicates the relationship between export activity and innovation by business size, age and innovation status, between 2010–11 and 2012–13 in Australia.

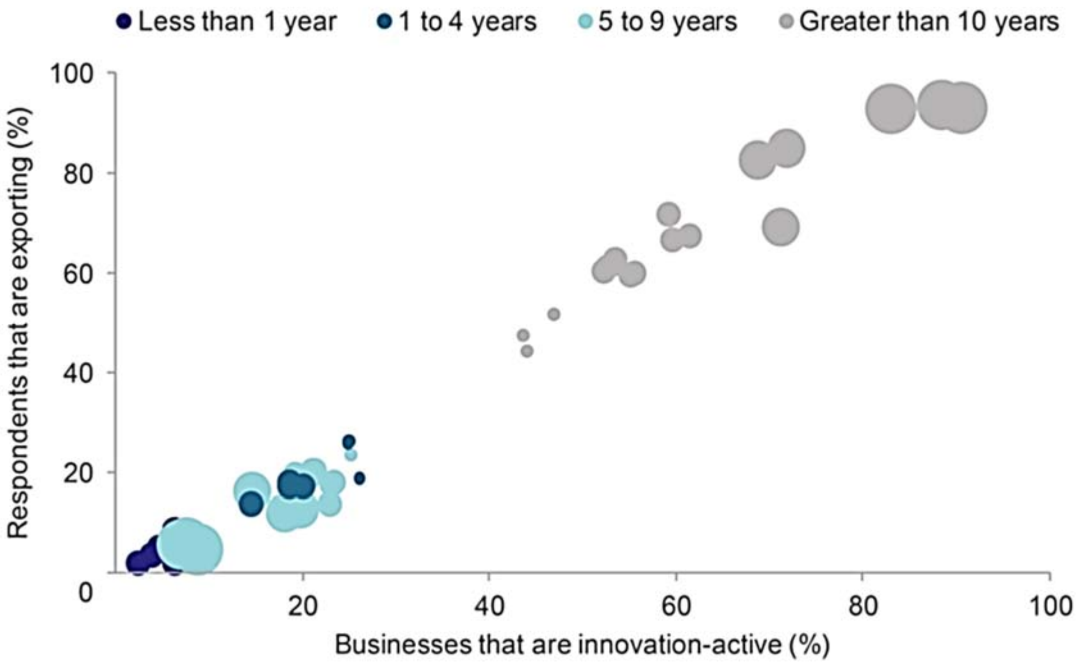


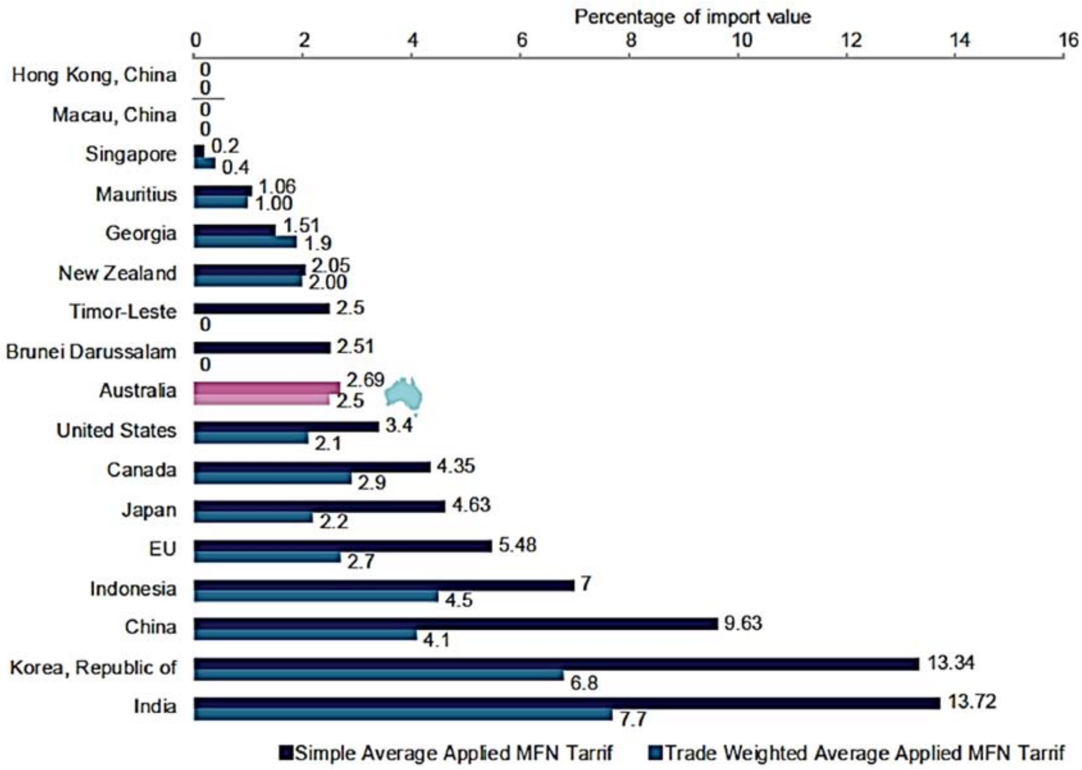
Figure 2.13: Relationship between export activity and innovation, by business size, age and innovation status (Hendrickson et al. 2014)[5]

2.9.1.1.2 Australian Innovation Environment and Government Policies

Innovation grows when there is competition and does not flourish in an economy with high levels of restrictions on the free flow of products and services. This has political impacts on the current Australian policies, especially when there are considerations for reducing the barriers in other countries while Australia is increasing them (Figure 2.14). It is important to note that although Australian tariff policies have been changed in recent years to reduce the protection of local businesses, restrictions can be caused by non-tariff factors such as quotas and import licences as well as technical barriers and trade costs (Soames, Brunker & Talgaswatta 2011).

---

5 Source: ABS (2014) Customised report based on the Business Characteristics Survey data commissioned by the Australian Government Department of Industry.



Note: Simple Average Applied MFN Tariff (2012 data, excluding Brunei and China 2011 data).
Trade Weighted Average Applied MFN Tariff (2011 data, excluding Timor and Brunei data missing).

Figure 2.14: Australia's tariffs compared to world's lowest and major trading partners (Hendrickson et al. 2014)[6]

Most would agree that the fewer barriers Australia has in inter-organisational, domestic or international policies, the more productive the technology transfer and the more innovative it will be. In order to create a policy and strategy that is functional, the technology transfer strategy has to focus on two improvements. One is the effort to expand the market. The other is the effort to reduce barriers to entering the market through active government support of adopting and promoting technologies.

The first basic element for an innovative nation to be a part of the technology transfer game is not to be the best in technology transfer but to invest in the most efficient and effective technology transfer processes (Levi et al. 2010).

6 Source: International Trade and Tariff Data, 2011 and 2012, World Trade Organization, www.wto.org.

This point is supported by the fact that seven out of the top ten trading partners of Australia are in Asia (Kelly & La Cava, 2014). Networking is the vital element for innovation and technology transfer. The Australian Innovation System Report clearly mentions that Australia has one of the weakest indices of networking, collaborative innovation and business capacity to engage and attract external knowledge, amongst OECD members (Hendrickson et al. 2014).

One substantial effect of poor networking is the lack of diversification and complexity of Australia's export market. Although Australia has diversified the national industrial-based products, its export index is dominated by mineral resources. This is why Australia has one of the lowest levels of export complexity of all OECD members. Studying the connection between innovation and export at the industry level, including technology transfer, illustrates a direct relationship between innovation capabilities in an industry's division and that division's international competitiveness (Hendrickson et al. 2014).

As a final point, despite Australia's appropriate response to the emerging economy's demand and its acceptable Foreign Direct Investment (FDI) inflow, its current situation in terms of export of mining products may be unstable in the long term (World Bank Group 2014). As a result, due to the lack of diversification in export, Australia could be at risk from global shocks and fluctuations of the economy. Although government support in all dimensions is mentioned as the key influencing factor, innovation is not the government's responsibility. Firms innovate and governments pave the way for growth and technology transfer possibilities by creating the right atmosphere for it. Consequently, this raises the question whether the Australian drilling companies are effectively covering the concept of innovation in their policies.

In order to see to what extent innovation helps firms, or to what extent barriers to innovation and technology transfer affect the country's economy, innovation will be investigated at a company level. According to the Australian Innovation System Report of 2014, innovative companies are: "twice as likely to export and five times more likely to increase the number of export markets targeted, twice as likely to increase productivity, employment and training, three times more likely to increase investment in information and communications technology, three times more likely to increase the range of goods and services offered" compared to non-innovative companies (Hendrickson et al. 2014).

2.9.1.2 Company Level

"*To innovate or not to innovate, that is not the question".*

-Dimis Michaelides (2012)

Leadership and innovation expert

Speaking about innovation to senior-level managers and industry leaders, although everyone is talking about it and nearly every firm interviewed reported wanting to be innovative, they did not provide a clear definition for innovation. In the end, it is neither an invention nor a scientific discovery, to be measured or proved by mathematical calculations (Michaelides 2007).

"Innovation is the process by which we change the world. Innovation to put it simply, is about how to make things better, in significant and hopefully meaningful ways. It is the practical application of ideas and technology to make new and better things. Innovation is hard. It requires taking chances, it requires challenging those things we think we know in certainty. It requires breaking the rules" (Bass 2012).

Basically, innovation is the art done by individuals, not the companies as a whole. Although innovation is done by individuals, innovation is never a solo act. People are more innovative when they do what they like. Connecting talents to their passions, creating a good team and creating an appropriate vibe for creativity is the firm's job. Innovation comes from imagination, from a creative mind and someone with problem-solving skills (Hendrickson et al. 2014).

Organisational innovation can be a very radical and breakthrough process, and can be divided into three types. The first type is when the product, the process and the service are new. The second type is when a firm finds a new way of conducting existing operations. Finally, the third type of organisational innovation involves an ongoing development scheme (Michaelides 2007).

To deliver innovation, the firm requires a structure to gather, assess and implement new ideas. For instance, reviewing employee proposal outlines, encouraging creative problem-solving groups or providing freedom, chance and time for employees' engagement in new ideas. However, implementing a new idea means risk and taking the risk means the possibility of failure (Hendrickson et al. 2014). This is why some believe that innovation is not a corporate phenomenon. Innovation is defined as breaking the rules and firms predominantly seem not to get excited about that. Having worked for a few years as a business development consultant, the researcher would say that firms perform exactly the other way round. Organisations tend to protect their health by narrowing activities and minimising risks, unless there is a reason to take a risk. This reason can be support or reward from a government.

Regardless of how Australian firms define innovation within the organisation, the results of their performance will be assessed at an international level.

2.9.1.2.1 Australian Firms' Innovation and Intangible Assets

From reviewing the facts and figures provided in the Australian Innovation Report of 2014, Australian companies seem to be somewhat innovative but Australia's exporters are relatively weak on innovation and innovation collaboration. The contrast in the Australian sector's performance is obvious. The Australian government report shows that although some companies and industries give a better impression than others in terms of innovation collaboration, Australian industries are ranked low amongst OECD members. as Australian industries also have a low capability to engage and use outside information that might advance their competitiveness (Hendrickson et al.

2014). Figure 2.15 provides a clear indication of Australia's position based on the firms' collaborative innovation activities.[7]

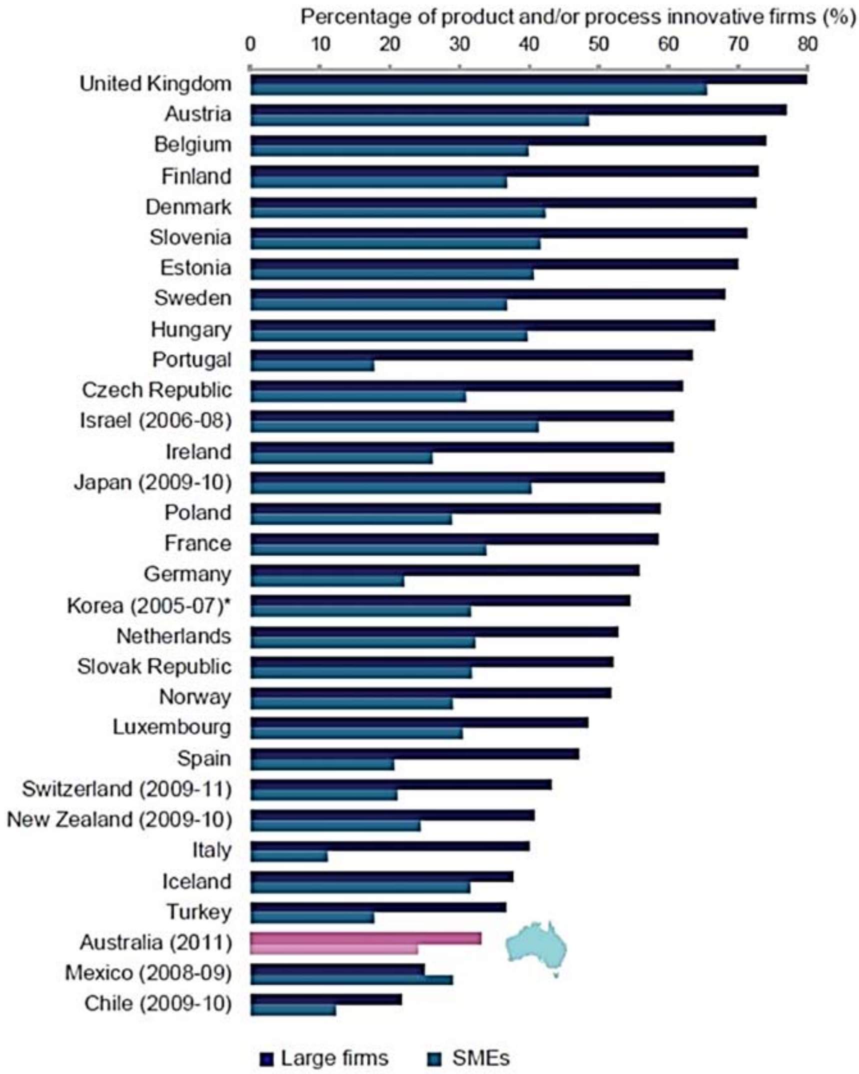


Figure 2.15: Firms collaborating on innovation activities (Hendrickson et al. 2014)[8]

The innovation-adopting capacity of Australian firms may be limited by low engagements of researchers in industry sectors and imbalanced sharing of researchers and research results in the private sector (Hendrickson et al. 2014). It is interesting that the government report indicates that Australian

---

7 Below figure refers to Korean manufacturing sector only.

8 Source: OECD, based on Eurostat (CIS-2010) and national data sources, June 2013.

SMEs perform relatively better than large companies in innovation by OECD standards (Hendrickson et al. 2014). These innovations are not inventive innovations, but are rather adopted and modified innovations. Australia has one of the lowest numbers of active innovators in R&D in the OECD and the weakest innovation support of the public sector across all business sizes and industries (Australian Bureau of Statistics 2014).

A series of systemic innovation concerns and management capabilities, if addressed, could considerably improve Australia's competitiveness. However, Australian innovation reports identify the most significant barriers to innovation in Australia as the lack of necessary financial aid provided by the government. Despite the lack of government funding, Australia has attracted funds through foreign investment which has expanded from US$150 billion in 2002 to US$611 billion in 2012 (Australian Bureau of Statistics 2014). However, the majority of this investment is absorbed by the mining sector (Hendrickson et al. 2014) and the Australian drilling sector. The question is the portion of the funds that has, or has not, been invested in the innovation side of the Australian drilling industry. As discussed earlier, Australia's investment in R&D is quite poor in comparison with other advanced nations (Hendrickson et al. 2014).

One thing that Australian industries need to realise is that although investment in new machinery and equipment is essential, it only achieves a portion of the innovation asset. This is mostly the case with the service industry, which is part of the drilling industry's supply chain (Haskel & Westlake 2014). Investment in intangible capital is a significant source of international competitiveness. A suitable foster linkage between productivity, innovation and intangible assets such as innovative organisational processes, management quality, brand equity, etc, can generate a remarkable value to the innovation asset, as well as goods and services (Cummins 2005).

More importantly, intangible assets significantly improve the productivity and advance the use of human resources, supplies and supply chain, as well as tangible assets (Sichel 2005). Unquestionably, there are further encouraging aspects of investment in intangible assets for companies, but covering all of them is beyond the limitations of this paper.

One of the most important intangible assets to be mentioned is research and development (R&D). The government report of 2014 indicates that between the years 2011 and 2012, only 45% of Australian firms invested in R&D (Hendrickson et al. 2014). As a result, Australia was ranked fifteenth amongst the thirty-four OECD members. Although the report shows that the Australian mining industry has been investing in R&D to a reasonable extent, the extent of neglect of R&D investment for other Australian industries and its effect on the Australian mining industry, particularly the drilling sector's supply chain, is yet to be determined.

The same report illustrates that R&D investment in Australia's manufacturing industry is also lower than the OECD median, particularly in high-technology manufacturing (Commission 2014). Australia's level of energy and material productivity is also poor by OECD standards. Australia's median annual labour productivity growth rate since 2001 has been only 0.8%, which is half of the OECD median at 1.6%, and a long way behind the top five members' median of 3.7%. The Australian mining industry seems to be the only area that has a notably high productivity index, well above the OECD average (OECD 2013a) as shown in Figure 2.16.

The low R&D, high-technology manufacturing and productivity index results caused such undesirable results in Australia's ranking of R&D and productivity. Whether this negative impact results from a niche area or the entire industry's culture, it is disturbing the supply chain of the Australian drilling division as well. With the recent decrease in the export trend occurring in the Australian mining industry, a downturn of the mining industry's good results and ranking is inevitable (Hendrickson et al. 2014).

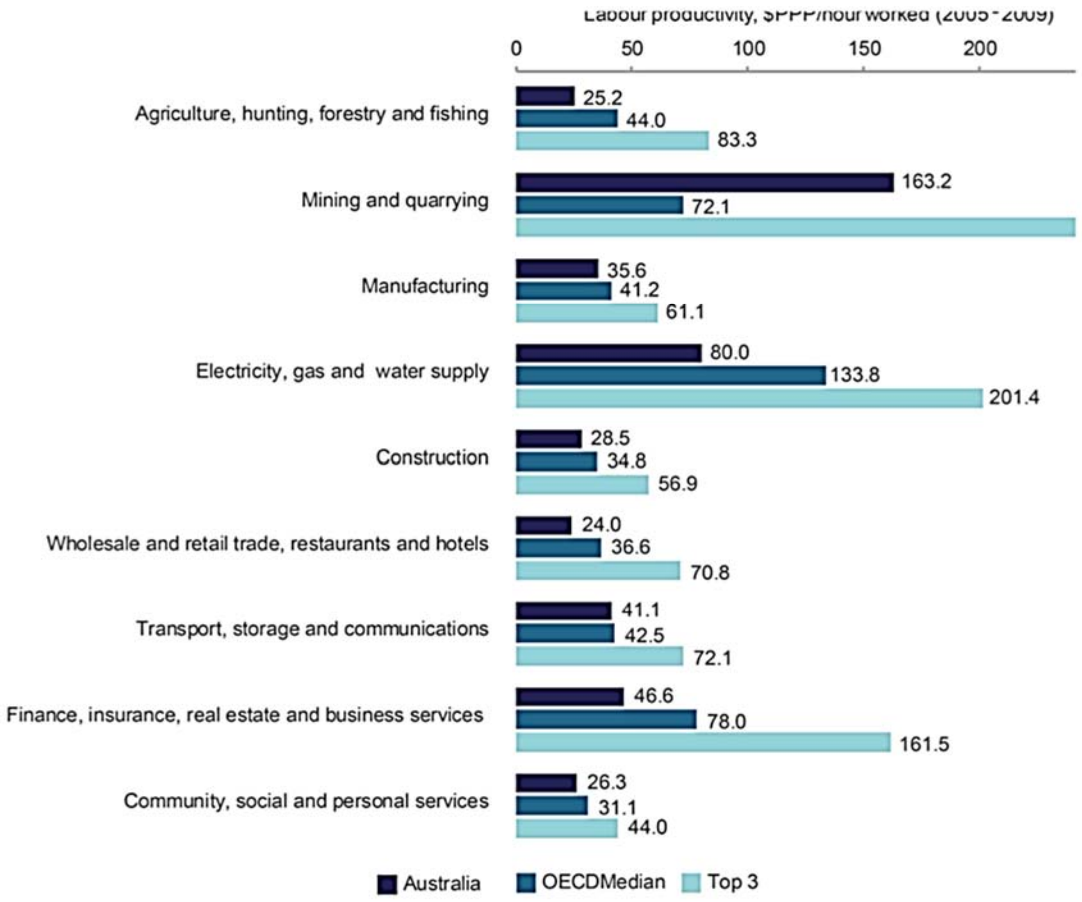


Figure 2.16: Average labour productivity in selected OECD countries by sector 2005-09 [9](Hendrickson et al. 2014)

2.9.1.2.2. Innovation Culture, Education and Skill Level

"Daniel, you are not here to think. Stop thinking.
You are getting paid to do the job we ask you to do…"
-My former Senior Assistant Driller- Onshore Rig, Unconventional Well Field

"Skilled people drive innovation and competitiveness by generating new knowledge and adapting new and old ideas to a changing world" (Bell et al. 2014). While knowledge and education can change the culture, the ongoing

9 Source: OECD STAN Database for Structural Analysis; ABS (2014) Labour Force, Australia, Detailed, Quarterly, May 2014, cat. no. 6291.0.55.003

relationship between skills, innovation and employment might be defined as a ‘virtuous cycle’ (Putz-Plecko 2008).

A recent OECD analysis revealed that a variety of skill levels in a country has a direct impact on the innovation level and the country’s economic performance. These factors are influenced by dynamics of the place of work (OECD 2013b). So, in an internationalised industry, competition is at a global level and competition is against best practices.

Consequently, sectors and firms must have skills and education of high standards. Although the rate of educated employees (25- to 34-year-old employees with a bachelor degree or higher) in Australian firms has increased from 14.3% in 1995 to 35% in 2013, Australia is ranked eighth amongst OECD members. It is quite surprising that although Australia has an established track record of high-quality education, the rank of educated industry employees is not in the top five OECD members. It can be concluded that a lack of interest in educated people, or a lack of interest in educating at universities, seem to be another poor industry quality and culture in Australia. In the government report of 2014, it was announced that a lack of local skilled people is recognised as one of the most significant perceived barriers to innovation in Australia (Australian Burea of Statistics 2013). Figure 2.17 shows a summary of innovative activities in Australian businesses. It is clear that only a third of businesses undertook innovation between 2010 and 2011.

Summary of innovative activity in Australian business(a), key indicators, 2010-11 to 2012-13

		2010-11	2011-12	2012-13
Estimated number of businesses	'000	764	776	770
Businesses that introduced any new or significantly improved(b):				
goods or services	%	17.3	20.4	20.0
operational processes	%	16.4	19.1	16.9
organisational/managerial processes	%	18.9	23.0	20.2
marketing methods	%	16.8	19.9	18.8
Businesses that introduced innovation (innovating businesses)	%	33.3	41.3	36.6
Businesses with innovative activity that was(b):				
still in development(c)	%	19.6	24.9	22.8
abandoned	%	5.7	6.9	5.9
Businesses with any innovative activity (innovation-active businesses)	%	**39.1**	**46.6**	**42.2**

(a) Proportions are of all businesses in each output category.
(b) Businesses may be counted in more than one category.
(c) As at the end of the reference period.

The proportion of businesses that were innovation-active (i.e. those that undertook any innovative activity) in 2012-13 was 42%, a decrease of five percentage points from the previous year.

Summary of innovative activity in Australian business, by employment size(a), 2012-13

		0-4 persons	5-19 persons	20-199 persons	200 or more persons	Total
Estimated number of businesses(b)	'000	466	243	58	4	770
Businesses that introduced innovation (innovating businesses)	%	28.9	45.8	58.3	66.8	36.6
Businesses with innovative activity that was(c):						
still in development(d)	%	18.3	27.8	35.6	51.4	22.8
abandoned	%	5.3	6.9	6.3	4.4	5.9
Businesses with any innovative activity (innovation-active businesses)	%	**34.7**	**51.0**	**63.4**	**74.3**	**42.2**

(a) Proportions are of all businesses in each output category.
(b) Business counts are provided for contextual information only, and the total may not sum to the total of the components due to rounding. Refer to Explanatory Notes 19 and 20.
(c) Businesses may be counted in more than one category.
(d) As at the end of the reference period 30 June 2013.

Figure 2.17: Summary of innovative activity in Australian business (Australian Bureau of Statistics 2013)

Figure 2.18, which is provided by the ABS, also indicates characteristics of Australian businesses in terms of supply chain integration, based on innovation-active businesses and non-innovation active businesses. This table provides a multi-angled comprehensive platform to compare innovative and non-innovative businesses from different aspects such as size, collaboration, R&D, etc.

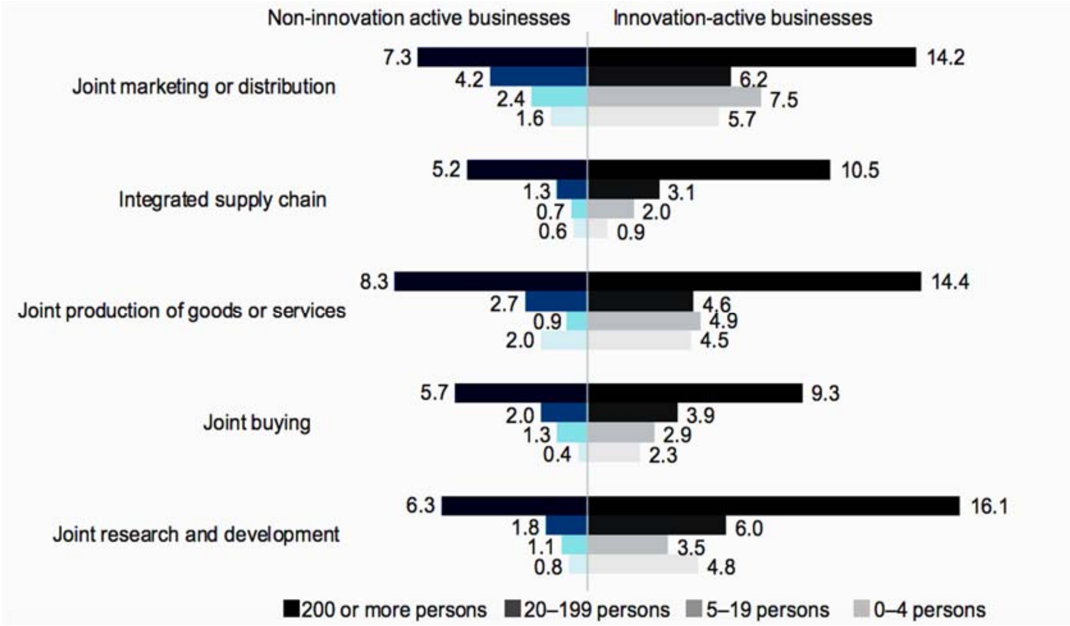


Figure 2.18: Collaborative arrangements, by innovation status and employment size (Hendrickson et al. 2014)[10]

To perform a comparative analysis of Australia's innovation performance with the rest of the world, the reasons behind the existing facts and the current innovation culture of Australia need to be inspected. In order to compare Australia's current innovation system with successfully innovative countries, two top-level performers of the Global Innovation Index and the OECD Better Life Index are selected. The two top-level performers chosen are Germany and Japan (fifth- and fourth-most innovative global leaders respectively).

2.9.2 Innovation at the Global Level: Top Performers

Germany and Japan are known for being among the best models of innovative countries within the innovation leaders. A few research papers have suggested that most emerging economies use Germany or Japan as an example at the core of their innovation system.

10

Source: ABS (2013) Selected Characteristics of Australian Business, 2011–12, cat. no. 8167.0, ABS, Canberra

2.9.2.1 German Innovation System

"As soon as we hear 'Made in Germany',
it means it is innovated in Germany, means trust,
and we don't need any other guarantee.
Throw away the guarantee card. We don't need it."
-My former colleague (2013)
Operations Manager of onshore completion and drilling

Germany, the largest national economy in the EU, has increased its funding in research systems, particularly in the energy industry. As a result, research and development in the private sector, universities and government bodies are also boosted (Allen 2009). Public financial aid in Germany is either project based or comes in the form of institutional funding. Therefore, innovation projects either receive support for an individual or research institution fund aid. In addition, the tax incentive scheme for research and development institutions is currently being discussed and the outcome is not yet confirmed (Global Survey of R&D Tax Incentives 2014). Germany has spent nearly 74 billion euros (almost 84.5 billion USD) on R&D between 2010 and 2012, which is more than any other European country (Eurostat 2015).

Germany's leadership in innovation on a global scale and specifically amongst European countries is quite firm (Lehnfeld 2013). In 2012, Germany's gross expenditure on R&D was raised to USD 94 billion, while Japan's budget was USD 160 billion. The United States of America has spent 447 billion. In contrast, Australia's gross expenditure on research and development in the same year was USD 22 billion. As some might argue that the R&D should be compared by GDP, it must be mentioned that Germany has a positive rank in research and development divided by GDP as shown in Appendix 1 (Hendrickson et al. 2014).

This means that the extraordinary funding backup is not the only significant factor for Germany's success. However, innovation superiority seems to be not only the German government's mission, but it is also supported by basic law and "habit" (Frauenhofer Institute for Systems and Innovation Research et al. 2008). Habit or rather German “work ethic” is the reason why Germans work fewer hours but produce more. The statistics clearly show that German employees work less than Australians and yet in those hours are more productive and even more innovative (Figure 2.19). Some might be familiar with this famous German saying: Working hours mean working hours (Sarva 2014).

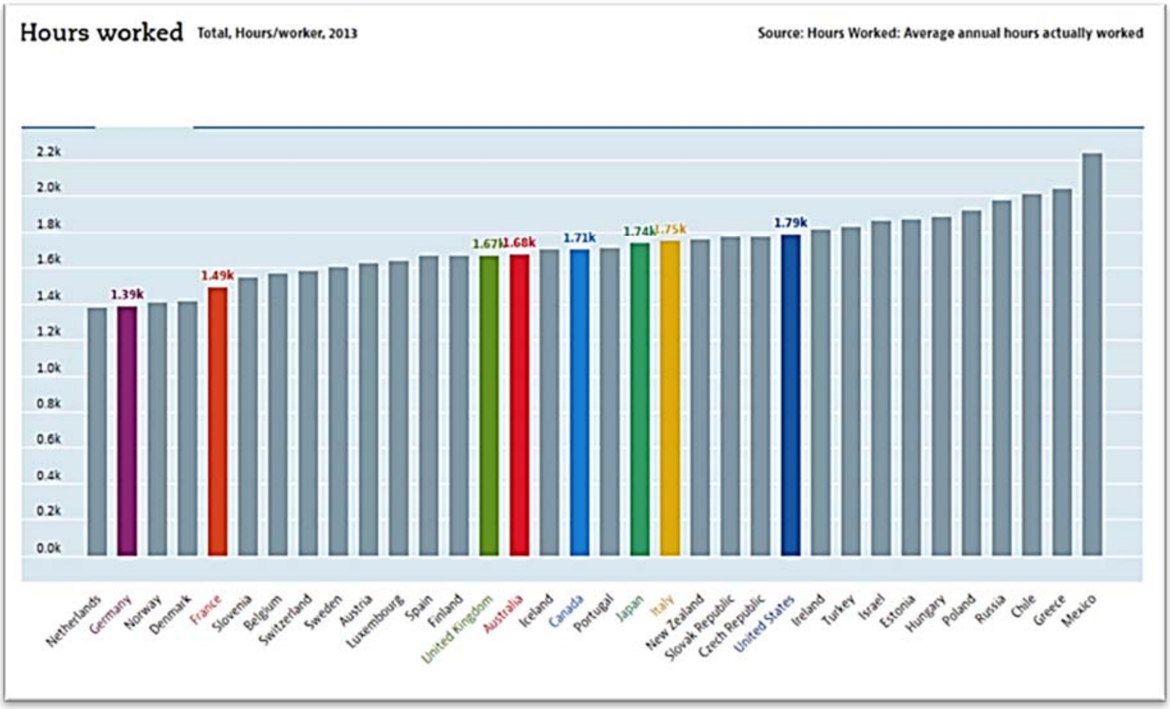


Figure 2.19: Hours worked (OECD 2013b)

2.9.2.2 Japanese Culture: Tradition, Loyalty and Innovation

There is a Japanese proverb that goes,
‘Raise the sail with your stronger hand,’
meaning you must go after the opportunities that
arise in life that you are best equipped to do.
-Soichiro Honda (Patrick & Helms 2006).

Before discussing the Japanese innovation system, it is essential to understand the historic motives of energy innovation in Japan. Japan’s Ministry of Economy, Trade and Industry (METI) forms the foundation of industry policy for the country. It came about in 2001 when Japan's Ministry of International Trade and Industry (MITI) was reformed and merged with other agencies (Ministry of Economy, Trade and Industry 2015).

METI has dictated the internationalisation, modernisation, technology procurement and investment guide for Japan. METI's foreign competitive policies have highly emphasised the R&D section of the policy, and left a watermark on the innovation culture of Japan (Johnson 1982). Although many, such as Mr Steven Lim, might argue that "*Japan's success may be despite, rather than because of MITI*" (Lim & Strutt 1994), the vital role of MITI in today's Japanese innovation and R&D success is not easy to ignore.

Another remarkable element in today's success in Japanese policies is the occurrence of the Keiretsu structure. This unique phenomenon was developed during the post-war era to create an interlocking business relationship between major Japanese companies, both as financial Keiretsu and industrial Keiretsu (Russell 1994). Mitsubishi Chemical is one famous example of a vertically integrated Keiretsu firm, where everything in the supply chain is knitted out into Mitsubishi Chemical (Galambos, Hikino & Zamagni 2007).

The advantages of the Keiretsu system are not only limited to financial security. Keiretsu public and industrial policies create a barrier against adverse international market competitions and takeovers. Technology transfer and knowledge transfer between Keiretsu members bring a larger pool of knowledge. They share the results of research and development to learn technology through their relationship. This mesh of integrated knowledge relationship creates a foster linkage between the technology leaders of the group and smaller suppliers in knowledge transfer, as well as forming an exclusive affiliation to form an integrated supply framework and an integrated distributor framework (Bagby 1992).

Another eminent factor in Japanese innovation success is evident in the Japanese working philosophy. Although some will discuss long working hours as a sin, work is a privilege, not an obligation in Japanese culture. Needless to mention, the Japanese management approach involves the team leader paying attention to the needs of team members, both personal wellbeing and professional needs (Wolf 2013).

Although there are more elements included in the prosperity of Japan and Germany within innovation and technology transfer government policy, innovation culture and working culture appear to be the most important factors behind their success, placing them both above Australia's position in global rankings.

2.9.2.3 The Tyranny of Distance is a Myth

Many industry leaders and managers mentioned that Australia's geographical position is one of the most vital barriers when considering technology transfer and innovation. The extent that this affects the innovation and technology transfer is the question of this section of the chapter. When quickly reviewing the Global Innovation Index, it can be seen that there are three countries, namely Japan, South Korea and Singapore, who are almost the same distance from western Europe and the USA (the biggest marketers and exporters of innovation and technology) as Australia. Japan was covered in the previous section for other reasons. Singapore was selected to be investigated further as it has the most interesting case. The island state has no oil or gas despite being the oil and gas hub of the region. It is also one of the most innovative nations, owning the most high-technology manufacturing lines in the world. More details of the Singaporean innovation system will be given in the next section.

2.9.2.3.1 Singapore

"At the end of the day, what have I got?
A successful Singapore.
What have I given up? My life."
-Lee Kuan Yew, the founder of modern Singapore
(Prime Minister's Office Singapore 2015)

Singapore does not have any oil and gas reserves and does not conduct any drilling activities. Similar to Japan, it imports a considerable amount of oil and gas (Yi 2010). Surprisingly, Singapore is the oil and gas hub of the region. The OECD specifies that one of the significant reasons behind Singapore's rapid growth is its industrial restructuring and constant technological upgrading (OECD 2013c). Another mentioned vital index for growth seems to be the public policy to encourage openness in their overseas collaborations. Finally, the third significant effective key factor seems to be ease of entering and investing in Singapore (Singapore Economic Development Board 2015).

Statistics presented by the energy industry of Singapore indicates that Singapore has one of the strongest equipment and oil rig manufacturing sectors in the world (Singapore Economic Development Board 2015). 95% of major oil and gas companies' headquarters are located in Singapore. It is also home to Keppel and Sembcorp Marine, the largest rig manufacturers in the world (Austrade 2015). In addition, 60% of all global oil-field equipment manufacturers have a manufacturing line in Singapore.

However, some may argue that the Australian high dollar value is the main reason behind the poor manufacturing system. As Figure 2.20 shows, the Australian dollar and the Singaporean dollar have had almost the same value in the past five years. Singapore has the world's largest single bunkering port and the third-largest refining centre after the US Gulf Coast and north-west Europe (BP Statistical Review 2014).

Figure 2.20: Currency Charts (AUD/SGD) (XE Currency 2013).

SGD per 1 AUD, 9 Aug 2005 00:00 UTC-6 Aug 2015 07:17UTC

AUD/SGD close 1.01382 low: 0.91252 high: 1.35707

As the Global Innovation Index ranking indicates, Singapore has improved from the position of eighth in 2013 to seventh in 2014 (Hendrickson et al. 2014).

2.9.2.3.2 The Law of Attraction

In order to be more accurate in our comparative analysis, it is fair to compare Singapore with an oil and gas city in Australia. Darwin seems to be the closest oil and gas city in Australia geographically to Singapore, at a distance of 3348 kilometres from Singapore (timeanddate.com 2015).

Darwin is Australia's most cosmopolitan city (Darwin City Council 2015). It has a higher quality of life than Singapore with an index of 222.84, compared to an index of 150.01 for Singapore. While the Safety Index of Singapore remains very high, Darwin's Safety Index is moderate. The Health Care Index of Darwin

is at a moderate level while Singapore's is high (Numbeo 2015). Darwin's property prices, traffic commute time index and population indexes are significantly lower than Singapore, which seems to be more relevant to the manufacturing and operation sectors (Time and date 2015).
Consequently, it is obvious that Darwin and Singapore are quite similar in terms of lifestyle. Comparing Singapore and Darwin is to prove that the tyranny of distance is a myth. It is also to reject reasons such as high dollar cost, long distance to western Europe and differences in quality of life, etc, as the main reasons behind Australia's poor manufacturing, poor innovation culture and technology adoption. Darwin is very similar to Singapore in many aspects, while Singapore is a more innovative state as well as a very attractive choice for oil and gas manufacturing, technology production and innovation.

Australia has the potential to not only be the deployer of the latest oil and gas technologies, but to be the exporter of innovation and technology to the world. However, the question remains unanswered as to what can be done in order to turn Darwin into a more attractive choice for the oil and gas industry. Also, what are the barriers to innovation that are stopping Darwin from being the hub of oil and gas innovation of Asia/Oceania?

2.10 Conclusion

The research on innovation in the Australian drilling was the result of the researcher's analysis of the supply chain of the Australian upstream sector. However, innovation and technology transfer appeared to be the most significant and the most influential elements of the supply chain affecting the Australian drilling industry. After all, there are more and more shreds of evidence of an innovation gap between different layers in the upstream of the Australian oil and gas industry, specifically the drilling sector, to support this hypothesis.

The concept of innovation management issues is related to the entire global oil and gas industry, not only Australia. One of the most significant characteristics of the global upstream industry is that although the oil and gas industry is advancing in terms of technology, the industry is not quite as eager to adopt and apply innovations. One of the reasons for this might be that it is not feasible to keep updating the entire system and the pieces of machinery for the sake of innovation, due to financial costs (Acha & Cusmano 2005).

In recent years, the oil and gas industry did not have a good reputation for R&D investment (von Tunzelmann & Acha 2006). Initially, the oil and gas industry was investing in finding new methods as the seven giants [Anglo-Persian Oil Company (now BP), Gulf Oil, Standard Oil of California (now Chevron), Texaco (later merged with Chevron), Royal Dutch Shell, Standard Oil of New Jersey (Esso/Exxon) and Standard Oil Company of New York (Socony)] were controlling 85% of the oil fields in the world. However, history changed after the IOCs lost ownership of the energy fields to the NOCs in the 1980s and early 1990s (Economides, Oligney & Izquierdo 2000). As a result, the IOCs have a lower share in oil money and less motivation to spend any money on R&D.

Some companies might argue that new technologies and innovations might require a new skill set, which might be the reason why the oil and gas industry and especially the drilling operations are reluctant to adopt new innovations too quickly (Afuah 2012). However, one important reminder is that although technological innovation is dealing with product-related innovations, process innovation is dictating the way the business innovation process and techniques of operations and productions are being managed (Schilling 2013).

These questions were posed to industry leaders from international drilling companies, servicing companies as well as project owners who are directly in contact with the energy-related sector of the Australian Government. The style and method of data collection and the findings from the analysis of data collected are explicitly explained in future chapters.

2.11 Summary

Earlier in this chapter, the literature around the supply chain concept and the supply chain components were explored. Following that, different layers of the supply chain of Australian oil and gas were discussed to narrow the research in order to identify the influencing factors and drivers for innovation and technology transfer in the supply chain of Australia's oil and gas drilling industry. The literature suggests that the innovation index in Australia is lagging behind innovative countries. A few well-known indexes (AEDC, Australian Innovation Report, etc,) have been used to compare Australia's innovation situation with the top five most innovative countries. In conclusion, it has been identified that researchers suggested the lack of innovation in Australian but they did not identify the barriers. This is where this researcher has identified the research gap in the existing literature.

The literature review investigated the definition and critical elements of innovation and technology transfer in an analytical way. It also addressed the local innovation framework within Australia and the comparative international ranking, as well as identifying the prompting dynamics that drive innovation in the industry. The research hypothesis was prepared and developed in the form of four questions:

To what extent does the Australian onshore drilling industry utilise the latest technological innovation? What are the key influencing factors for innovation and technology transfer within the Australian onshore drilling industry in terms of supply chain and its operating environment? How do the key influencing factors create and promote barriers to the innovation and technology transfer? To what extent do the barriers influence innovation and technology transfer?

As a result, the gap has been identified and a few reasons have been suggested as the main barriers to innovation in Australia. However, one hypothesis suggested in this paper is that Australia is neither innovative in the drilling sector, nor utilises the latest drilling technologies. Another hypothesis based on the literature review is that the lack of collaboration on the global scale negatively affected the transfer of the technology to Australia as well. However, through the literature review, a comprehensive analysis of the existing perceived barriers, the value chain and the development of the supply chain in innovation and technology transfer are addressed.

CHAPTER 3: METHODS

3.1 Introduction

This chapter details the methods on which the research and findings are based. There are diverse approaches to this type of research in the oil and gas drilling sector, and the majority of these approaches are quantitative and profiled from the literature. The research in this thesis is primarily inductive in nature and it involves a fact-finding mission to find an answer to a question (Buckley et al. 1976). During the process of data collection, the choices and design of methods are constantly adjusted and modified, based on ongoing analysis. This provides the ability to investigate new areas and drop investigations of irrelevant issues from the proposed research plan.

There is a need to justify the question of validity and reliability in the selected research methods. The aim of the research is to gain a deeper understanding of the reasons behind the perceived barriers to innovation and technology transfer. Hence, a qualitative method such as a case study approach was preferred. Since a qualitative approach is adopted, reliability can be achieved by data triangulation. The data triangulation in this research is a mixed methodology approach which consists of the individual survey interview, focus group, semi-structured interview and documentations. The researcher has heavily relied on research tools such as the generalisation method and data triangulation to constantly refine the objectives and area of the study.

It is important to mention that the participants were extremely carefully selected from all the available choices. The researcher has referred to his ten years' worth of industry observation and networking, as well as his personal journal gathered in three years working on the operations side of Australian drilling. These particularly chosen participants are from operations, technology development and innovation departments of Australia's main oil and gas players, such as Santos, QGC, Origin, Saxon, Savanna, Easternwell and Schlumberger (who are directly involved in operations of Australian drilling).

The main hypothesis of this research originated from the researcher's interaction with around 200 industry participants who have been directly and indirectly involved with the Australian oil and gas drilling industry. After identifying the blind spot in the findings, the author travelled internationally to address the gap. Out of thee 200 participants, 20 key global leaders were interviewed in Indonesia, 30 participants in Malaysia, 30 in UAE, 30 in Canada, 20 from the USA, 20 from Europe and the rest were in Australia. These participants gave a holistic overview of Australian and global drilling visibility. The results of the research were then discussed in the form of a survey, interview and group meeting with thirty carefully-selected participants at the end.

More details on the reasons behind the selection of participants, adopted methodologies and methods are given in the next section.

3.2 Research Methods

The purpose of the research was to identify the perceived barriers to innovation and technology transfer within the Australian drilling industry's supply chain network. A mix of qualitative and quantitative methods were implemented in a case study approach. Many sources have discussed the values of combining methods as it helps to enhance and extend the logic of qualitative explanations (Yin 2008). According to Ritchie & Lewis (2003), when qualitative and quantitative methods are combined to study the same phenomenon, they can offer a detailed analysis.

For this research, qualitative investigation methods were required for analysing the integration processes and quantitative methods required for outcome measurements. Therefore, these techniques can provide comprehensive data on the role and impact of engineering technologies in the gas drilling supply chain and reflect a range of perceptions from surveys, interviews and quantitative presentations to gain a detailed understanding of the phenomenon (Bryman & Burgess 1994).

3.2.1 Qualitative Method

A qualitative case study is a strong tool for analysing a complex phenomenon. If it is utilised correctly, it can be a powerful engine to develop theories, evaluate hypotheses or plan an intervention (Cooper and Schindler 2003). It enables the researcher to investigate an industry, a sector or firms. According to Yin (2003), the case study method can be used when the researcher is trying to target the “how” and “why” questions. This is the most relevant method to answer “what are the barriers?” and “why do the barriers exist?”.

Neither the quantitative nor the qualitative case study is complete on its own. In this study, each method individually cannot answer questions fully. In this case, a qualitative case study can provide a holistic overview of the phenomenon. “Quantitative data, no matter how rigorously collected, is still vulnerable,” and works best when the dependent variables are few and manageable by the researcher (Smelser 1973).

None of the methods on its own can provide a detailed answer to the complex questions of this study which are beyond the scope of quantitative methods (Steckler et al. 1992). This is the main reason that the mixed method of relying on both qualitative (for deep investigation of the phenomenon) and quantitative (for measuring the impacts of the barriers) has been chosen for this study (Inui & Frankel 1991).

A vital point on focusing more on the qualitative method than quantitative is that the qualitative socio-cultural field method offers an insider’s view, as the researcher will interact with participants in their own area and speak their language- the industry language. Also, the data gathered are derived from participants’ years of experience and from the heart of the industry with no bias modifications. This can be an invaluable tool for evaluating the findings through literature review and other quantitative studies (Lakshman et al. 2000).

It is important to mention that qualitative data are not merely a diary or life stories but a representation of the real world and the industry's specific problems which enable researchers to provide a practical solution (Yin 2011).

3.2.2 Case Study Research

Qualitative methods can be categorised differently. According to Creswell (2012), qualitative methods include ethnography, narrative, phenomenological, grounded theory and case study. Although all five methods follow the same basics, the objectives of the research distinguish them (Creswell 2013). Case study qualitative research, however, adds value in analysing a sector, an industry or an event.

As a case study involves deep investigation of a phenomenon through multiple data sources such as data triangulation, it was deemed to be the most appropriate and applicable method to adopt for this research. The case study domain is selected based on its perceived relevance and appropriateness, given the nature of the research problem and the research context (Yin 2013). A case study is especially suitable for learning a situation with little background (Leedy & Ormrod 2005) and, as noted earlier, there is very little drilling supply chain integration research and practice in the Australian oil and gas industry. Hence, in this research, a case study is utilised to explore the roles of engineering technologies in the supply chain portal in the Australian context.

For the purpose of this proposed study, two sources of research are used: primary and secondary. Primary research is conducted using two methods: surveys and interviews. The secondary data come from documentation and literature. The final findings are evaluated through a focus group interview and the data is mainly collected using an integrative approach. The interview is conducted to gather information from industry experts and the target population of this study comprises drilling industry participants. The main targets are senior-level supply chain managers, operation managers, supervisors and engineers in drilling companies who have projects in the Australian drilling industry.

3.3 Triangulation Mixed Method

In order to establish the validity of the qualitative study, assure the consistency of the results and avoid bias perspective, the triangulation method has been chosen for this research (Patton 2011). The researcher has involved diverse sources to increment data validation, which is known as data triangulation (Patton 1999). Also, as explained in the research method section, a mix of qualitative and quantitative methods has been utilised in order to reinforce the accuracy of the research results and for better interpretation of the phenomenon and to provide the most insight (Yin 2008).

As a part of this methodological triangulation, the researcher has taken advantage of powerful data collection tools such as interview, focus group, observation and literature review analysis. The mentioned mixed method, although time-consuming, has been used to bring confidence to the findings, reveal the unanswered questions in blind spots and to develop a sophisticated understanding of the case (Denzin 1978).

3.3.1 Data Collection

The research objectives and questions are approached by three main activities, as shown in Figure 3.1.

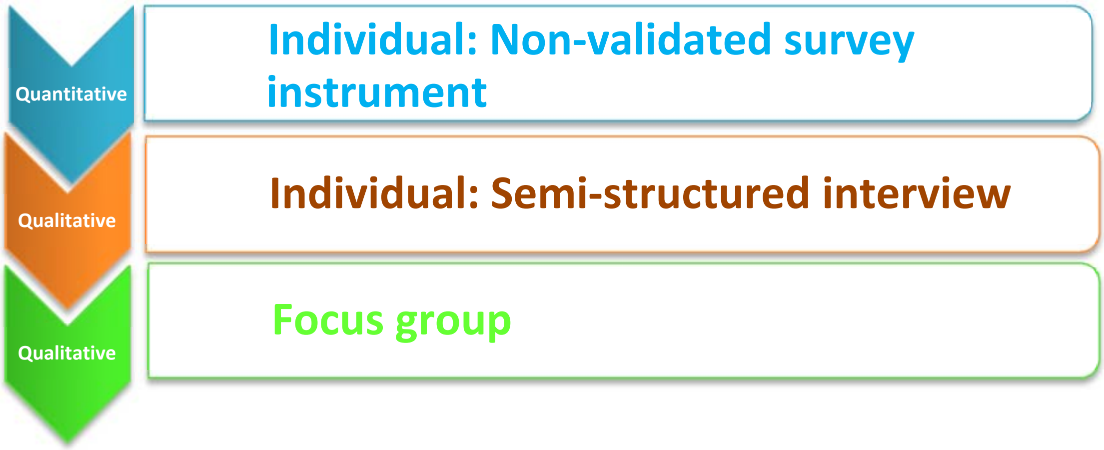


Figure 3.1: Data collection methods

The three research activities are as follows:

1. Investigating the perceived barriers to innovation and technology transfer within Australia's drilling industry's supply chain network through data collection. A non-validated survey instrument will be used, as only a qualitative data collection will be conducted.

2. Evaluating technology transfer mechanisms and the supply chain and operating environment in order to answer the sub-questions. This method of data collection will be conducted by a survey instrument on a focused group of engineers, experts and managers.

3. Conducting semi-structured interviews to gather the perception and assessment of the previously collected data and also achieving more detailed information regarding the results.

The self-administered surveys were conducted twice. The mail survey was the method selected as it is the most efficient means for collecting data from respondents from companies located across a range of geographic areas in Australia (Churchill 1999). Another type of qualitative data collection method is the electronic survey, where an online survey service such as Survey Monkey was chosen as an appropriate survey tool. The survey was sent to the selected group of participants based on their position and experience in the global oil and gas industry and their involvement with the Australian drilling sector.

The first survey was carried out at the initial stage of data collection. The survey questionnaire, as shown in Appendix 3, consisted of two parts. To complement the interviews, a survey was distributed to collect demographic data and inform the target population about the case study research. The survey also served the purpose of saving time at interviews, as the background information of the participants was already obtained (Churchill 1999; Leedy and Ormrod 2005; Yin 2008).

The requested information included work experience within the Australian oil and gas industry, as well as international experience, industry education, academic education (if available in their profile), etc. It was expected that the demographic information collected from the survey would be useful in establishing rapport during the interview process, since the interviewer would have gained some knowledge about the participants (Cooper and Schindler 1998; Yin 2008). The second part determined the attitudes and the perceptions of the respondents with regard to the perceived barriers. The feedback from respondents identified the applications of engineering technologies and their implementation in the supply chain portal. It is important to mention that most participants independently mentioned and agreed on the existence of the perceived barriers addressed in the research. Most participants mentioned the barriers without previous knowledge of the research done by the author, as they were dealing with them during their work in Australia.

The second survey questionnaire was administered after the first survey. The objective of the second survey was to reinforce the first survey data with additional insight before starting the first interview. Moreover, it gave the researcher further confidence in the first interview by confirming the information obtained through the surveys. More details about the methods of research and surveys are provided in the next sections.

It is important to note that any information which leads to identifying the participants, including the survey, interview and focus group answers, cannot be included in this research as it is against the USQ ethics code of conduct.

3.3.1.1 Generalisation in Qualitative Studies

The technique of generalisation appears to be the foundation of research works. Starting with one observation, the concept to further interpretations for supplementary conditions for truth findings is developed. Generalisation is recognised as more of a controversial method in qualitative research than a concept to generalise a fact. This is how the questions are raised and the research is shaped. The objective of the qualitative approach used in this research is to deliver a profound understanding of the study, rather than generalising it (Polit & Beck 2010).

Generalisation appears to be the core of all scientific research. Philipp (2007) explains that, in generalisation, “from single observations we try to draw inferences to more general formulations to be extended to future situations” (Flick 2005). The same source highlights the importance of generalisation to explain differences between elements of research such as age, gender, typologies, etc (Mayring 2007). Philipp argues the necessity of generalisation in qualitative research, on the condition that the purpose of generalisation- about rules, regulations, or context-specific statements- are clearly defined (Flick 2005).

Consequently, generalisation seems to be a significant tool for the qualitative study as long as the elements, the context and the purpose of the generalisation are defined.

3.3.1.1.1 Interview

The purpose of this research and the culture of the oil and gas industry have influenced the choice of the research methods and, specifically, the interview type. To obtain a more accurate analysis in this study, the primary data collected to reflect the personal understandings, perceptions and opinions of the participants was achieved by using a semi-structured interview, comprising open-ended questions. This focussed the interview by providing a predetermined guide towards a specific topic and kept the interview within the relevant theme and timeframe. Although the interviewer had prepared a predetermined interview guide, the semi-structured interviews offered the participants a chance to discuss relevant issues that they perceived to be useful and important to the study (Pitman & Maxwell 1992). The prepared interview guide increased the comprehensiveness of the data for the participants (Pitman & Maxwell 1992).

The raw data of this case study was obtained from interviews conducted with key managers, staff in supply chain operations, supervisors and engineers in the oil and gas drilling sectors. Key groups of experts and researchers in the oil and gas supply chain, drilling and technologies were also included. Prior to the interview, the participants were contacted and briefed on the nature of the questions in order to gather their thoughts on the areas of exploration. This allowed informants to gain some knowledge of what to expect, and they were mentally prepared.

The semi-structured interview lasted about 30 minutes. During the interview, the transcription and the initial data analysis were concurrently carried out to develop and ensure a systematic data collection (Minichiello, Aroni & Hays 2008). Based on the initial data analysis results, the phases of the research were constantly adjusted.

The next step of data collection was carried out for a targeted population consisting of a group of experts selected based on the result of the previous interview. The targeted population was invited to participate in a discussion of the collected data. The participants were provided with a “Code of Conduct” and “Chatham House Rules” to avoid any conflict during the conversation. However, the interviewer constantly guided the participants through a range of questions to invite any clarifications.

The participants were asked to provide relevant examples of claims to support their statements. Another technique used to encourage conversations of the participants was to begin each new section by asking the questions in a conversational flow and creating a linkage between the previous and the new topic. In qualitative research, the study does not attempt to generalise the answers provided by the interviewees. The study is seeking a series of commonly-addressed issues and concerns rather than trying to identify the number of occurrences of the subjects across groups. In addition to the face-to-face or telephone interviews with each participant, email interviews were conducted for the cases where additional details were required in supporting the prior information supplied by the participants.

3.3.1.1.2 Documentation

The parallel activity was the collection of secondary data from internet sources, books and publications; “For the case study, the most important function of a document is to corroborate and augment evidence from other sources” (Yin 2013). In addition, the findings helped the researcher make a reasonable inference (Yin 2013). This research made good use of all kinds of documents to get relevant data, including newspaper articles, administrative documents (proposals, progress reports, internal records, etc.), formal studies and community newsletter articles (Merriam 1998; Yin 2013). The interview questions were modified and updated after analysis of the survey results (Appendix 4).

3.3.2 Interview Questions

The survey questionnaires and interview questions were shaped and developed by the researcher, based on the literature review and previously validated survey questionnaires related to the oil and gas drilling supply chain. The below sample is based on the research questionnaire conducted by Romaiha (2011).

1. To what extent does the Australian onshore drilling industry utilise the latest technological innovations?

2. What are the key influencing factors for innovation and technology transfer within the Australian onshore drilling industry in terms of the supply chain and its operating environment?

3. How do the key influencing factors create and promote barriers to the innovation and technology transfer?

4. To what extent do the barriers influence innovation and technology transfer?

3.3.3 Active Observational Methods

Collecting information for research purposes can be undertaken in different ways. One of the qualitative research methods chosen was observation. In this case, the researcher used his powers of observation and presence in the relevant situation as the tool for collecting information. The understanding of the issues and concerns related to the technology transfer initially raised the question when working within the industry for about ten years. The hypotheses were raised from the heart of the industry when the researcher was conducting duties and working with expats raising concerns about the Australian drilling. As years passed by, the issue became more obvious for the researcher.

In this study, the researcher involved himself as an observation research tool, relying on years of consultancy in business development of the oil and gas industry in the Middle East and Southeast Asia. The researcher encountered the issues of the technology transfer barriers while working for the onshore drilling industry of Australia and specifically through working on the onshore drilling rigs.

3.3.4 Analysis in Extracting Meaning from Data

The researcher found that undertaking research often created a feeling that not enough evidence and data were collected. This caused over-analysing and overdoing the information collection, which eventually caused confusion for the researcher. This point can be addressed by providing some examples, but establishing a case was a challenge. Often the researcher collected more data and evidence than needed to support the research, as the researcher often fell into the trap of mixing the definitions of data and evidence.

Digging for more information related to the evidence was very challenging, as the researcher had to continually compare the previous findings with the new findings and frequently evaluate and replace the less important data with new data. This stage heavily depended on the analysis skills of the researcher to create the flow. However, the qualitative study also required technical analysis.

For quantitative data, the data from questionnaires was analysed by using a Microsoft Excel spreadsheet using different statistical tests. For qualitative data, content analysis was adopted to analyse the data. Two steps were carried out: identifying substantive statements and constructing categories (Gillham 2000). Overall, the entire course of the data analysis focused on coding and highlighting any recurrent themes related to the integration of engineering technologies in the oil and gas drilling supply chain management (Bryman & Burgess 1994).

3.3.5 Documentation and Journaling

Some highly-effective people have the habit of keeping details of their thoughts. These journals not only reflect the ideas and analysis of the external events, but also show the process of decision making, judgments and the journey of thoughts. Keeping a journal of research can illustrate the development of the research process.

A journal expresses the course of critical reflections, ideas, motives and causes of adjustments. Consequently, it shows the critical decision making and deviations in the journey of research. A good journal of research can support the development of the research and professional skills. The researcher used his personal journal and notes during his observations as a valuable source of data for his research.

3.3.6 Ethical Issues

There is still an argument over the ethics of the qualitative method. One of the issues is the amount of influence the researcher can have in implying the ideas in participants' thoughts and how much influence is acceptable (Denzin 2000). Another issue is the relationship development between the participants and the researcher. Although human nature forces the relationship to cause the possibility of biased answers, all aspects of professionalism were observed to avoid any unnecessary personal relationship development between participants and the researcher.

Ethical considerations were carefully observed during the research process. Permission to conduct the research study was obtained from USQ's Office of Research and Higher Degrees prior to the commencement of any data collection. All participants attended with the knowledge that their results would remain confidential. Before and during the data collection phase, the purpose and expected benefits of the study were explained to the participants. An information sheet containing a summary of the study was provided to each participant and each participant was required to complete a consent form before the commencement of data collection (Cooper and Schindler 1998). Please note that any details that might directly or indirectly contribute to the identification of the participants were removed from the paper as this is against the USQ code of research ethics.

3.4 Methodology and Methods Summary

The foundation of this chapter is based upon the elements of a case study and observations of the researcher during ten years' involvement in the international oil and gas industry, including three years of working within the onshore drilling industry of Australia. This chapter detailed the methods used for this research based on the qualitative methods, in which the consistency of the findings is examined through the data triangulation method.

Also, the methods of data collection are explained and supportive tools are described. As explained, this study is based on the semi-structured interview method and open-ended questionnaire in order to answer the questions of:

- What are the key influencing factors within the Australian onshore drilling industry, regarding the technology transfer mechanisms, supply chain and operating environment?
- How do the key influencing factors create barriers to the technology transfer mechanisms, supply chain and operating environment?
- Why do these barriers exist?
- To what extent does the Australian drilling industry utilise the latest technology?
- To what extent do the barriers influence the utilisation of the latest technology?

Finally, the result of the data collection was presented to a focus group for data validation.

CHAPTER 4: DATA ANALYSIS

4.1 Introduction

The data used for analysis in this chapter is based on quantitative and qualitative data collected through a survey of twenty industry leaders, interviews of ten participants and a focus group of five key industry leaders. These carefully selected participants were chosen from the pool of 200 candidates who initially contributed to the hypotheses and have been in contact with the author through the period of five years of this research. The answers given during the survey were analysed using a Microsoft Excel spreadsheet and the answers given during the interview by each participant were highlighted and compared with each other.

The researcher chose survey and interview participants from Australia who, in the past, have been involved in drilling operations, drilling technology and/or innovation management internationally. Amongst the possible candidates, preference was given to the leaders with international experience as they could compare Australian drilling to other operations around the globe.

The Australian Government Department of Employment has provided an industry outlook report on the mining industry and the relevant divisions. It appears that Australian directional drilling, re-drilling and mining draining as well as oil and gas field support services employ around 34,100 people which is 13.7% of the total mining industry's number of employees (Australian Government Department of Employment 2014). The Australian Bureau of Statistics explained that 50% of these employees were located in Western Australia, 28.2% in Queensland and the rest were spread around the other six regions (Australian Bureau of Statistics (May) 2016).

Understanding the fact that most drilling employees of Western Australia (WA) were related to offshore, our source of the sample decreased dramatically. Less than 21% of the targeted population had a university education (Australian Bureau of Statistics 2013) and only 2.6% were at the management level or the executive level which were a part of decision-making processes and procedures (Australian Bureau of Statistics (Sep) 2016). Consequently, the targeted survey and interview participants were around two hundred people across Australia. Initial involvement with ninety participants was targeted for the data collection. Thirty participants out of the ninety participants who were in Australia agreed and responded to the survey and interview invitation. Thirty participants was a valid sample to address the issues.

The carefully chosen participants from a vast pool of knowledge and experience were given the opportunity to go beyond the boundaries of the research questions in order to provide a more detailed and collaborative result. Open-ended questions were specifically designed to give these well-selected participants the chance to explain the issues more fully, in order to evaluate the findings accordingly. This chapter illustrates the results of the survey and answers to the interview questions.

The analysis of the abovementioned data addressed a gap and a blind spot in the data collection. The data showed that due to a lack of networking and international collaboration between Australian drilling and the global oil and gas industry, the data collected was incomplete. Consequently, the researcher took a further step in order to collect data from a different group of participants who were chief executive officers (CEOs), directors of operations, chief operating directors and other participants from the industry's executive levels. The result of the data collection is provided in detail in the next chapter.

4.2 Implications and Applications

The initial assumption was that the Australian drilling industry does not employ the latest drilling technologies. In contrast, the survey data shows that 54% of the industry leaders strongly believe that the latest drilling technologies are available in Australia and also 24% of the participants believe that to some extent Australia does employ the latest technologies. Hence, the contrast between the literature review and the survey appeared to address a gap in the research. However, the question was raised during the extensive interviews for more clarification on the matter. Participants' answers indicated that although the available technologies in Australia are relatively up to date, they are not necessarily the most efficient or innovative technologies.

To address the research gap, the researcher attended the 2017 Asia Pacific Oil & Gas Conference and Exhibition (APOGCE) shown in Appendix 6. This data collection journey was to identify the latest technologies which are not available in Australia and barriers which stop the latest innovations and technologies from entering Australia. At APOGCE, the challenges, potential solutions and technological advancements to meet Asia Pacific's growing energy needs were discussed (Society of Petroleum Engineers 2015).

APOGCE also had a strong multi-disciplinary technical programme that featured more than two hundred peer-reviewed technical papers and timely executive plenary and panel sessions to address critical topics in barriers to development, Liquid Natural Gas(LNG)/Floating Liquified Natural Gas(FLNG), unconventional oils, mature fields and asset integrity (Society of Petroleum Engineers 2015). Interviewing distinguished renowned industry leaders and experts at APOGCE added significant value to the findings.

From the interviews, one of the facts mentioned by a few participants was that "there are no advanced technologies which cannot be brought to Australia" and, surprisingly, geographical position was mentioned not to be the biggest concern in technologies entering the Australian market. "The companies can overcome the distance disadvantage, but the main issue is the size of the country itself. When we think of introducing a new technology to Australia, logistics is a nightmare."

Another participant addressed the same facts and added that for example Canada or the USA are similar in size to Australia but logistics and supply chain are not an issue in those countries. Supporting, managing and achieving the economy of scale for a few hundred drilling rigs in North America is easier than supporting only a few rigs, which are located far apart from each other, in

Australia. Most participants also addressed poor manufacturing and a lack of support from the third party service providers as an issue when considering business development in Australia.

A participant from one of the largest and most innovative drilling companies in the world stated that, “entering the Australian market is a great opportunity but not a great development” in terms of innovation and technology management. This participant stated, “the lack of continuity of the project is the main motivating factor for not bringing all applicable technologies to Australia.” Australia was mentioned as a market that requires a heavy investment with no consistency for future market employment when compared to other locations.

One of the most distinguished industry leaders, while confirming the same facts, answered the question of “Are these facts stopping your company from bringing the latest technology to Australia?” by stating that the technology and knowledge are no longer an issue in the global oil and gas industry and in Australia. The key factors in today’s oil and gas world are having proper access to infrastructures, regulators and having appropriate innovation collaboration between leading companies. This participant was asked to elaborate on his answer and explain about the possibilities of innovation and technological collaboration in such a competitive market. The answer was that collaboration between big oil and gas companies is extremely complex but possible. More collaboration within the industry and with government sectors is where the future of oil and gas is heading. Few would disagree that this can be the collaboration model for Australian drilling companies as well.

The same question was taken to some IOCs (International Oil Companies) and multinational companies, who have access to a wider range of onshore drilling technologies. It appeared that since the involvement of Australian drilling in the international onshore market is limited, the local industry is not aware of the latest innovations and technologies. An industry leader, who is in charge of drilling technologies at a local drilling company, addressed this issue during an interview. According to this participant, there are multiple advanced technologies which can be introduced to the Australian drilling industry but the

Australian industry's current culture is "does not like changes" and challenging any new technologies that require changes.

This same participant mentioned that one of the biggest issues of technology transfer is that the Australian drilling industry (and particularly Queensland's drilling industry), does not know about the latest technologies due to a lack of networking. Additionally, the participant went on to report that, "Even international exhibitions in Australia are not strategised appropriately in order to aim to update the industry. Australian oil and gas are not interested in participating in international exhibitions to learn from key global leaders. This is the reason why the Australian drilling industry does not know what they do not know".

As mentioned in the literature review, Australia has untouched oil and gas reservoirs. This may make Australia a relatively small market for technological competition. It has also been reported that the available drilling related technologies fulfil the required purpose. Thus, there is a belief that the Australian drilling industry does not require faster or more efficient facilities as the current supply matches the demand.

As mentioned by Perrons (2014), the international oil and gas industry is slow in adopting new technologies. However, it seems that the Australian drilling industry- regardless of the existing potential- is even slower. Having a closed environment which relies on technology offers from the international companies rather than creating a proper innovation policy to support technology transfer is something that policy makers need to consider.

4.3 Study of R&D Culture in the Australian Drilling Industry

One of the interview participants from the R&D department of the project owner companies addressed one the most significant scenarios mentioned by the participants. It was reported that in recent times, a very advanced technology was introduced to the company and the R&D budget was allocated to explore the possibility of utilising this specific technology. After testing the technology, it was proven that, in the long run, the targeted technology would have saved the company a significant amount of money.[11] However, since the technology was new and no one else in Australia had employed this specific technology before, regardless of the financial benefits in the long run, the company was not interested in developing this project further and the necessary R&D funds did not get approved. This raises the question of why did the company invest in the R&D project in the first place. Moreover, how many R&D budgets have been wasted or wrongly targeted in the Australian drilling industry thus far?

This is another indication that the Australian industry is after short-term, quick results as well as having a low tolerance for risks, regardless of the possible values. Another issue frequently reported by most participants was that any sort of new activity and innovation is weighted by the amount of return in investment. “If the return cannot be anticipated as being big enough in the short term, the R&D budget may not be granted”. However, “R&D is about long-term vision, taking risk and possible failure”.

This is where the conclusion can be drawn that the Australian drilling industry might not have an encouraging innovation pattern in place. In addition, even Australian non-drilling industry organisations might not have a clear innovation policy in place. It is important to note that 67% of participants mentioned that the concept of innovation is not covered by their company policies. Also, the survey participants indicated obstructive government policies and poor government procurement of innovation is only 10% of the key influencing factors for innovation and technology transfer within the Australian onshore drilling industry. Consequently, innovation and technology transfer seems to be a missing piece of the puzzle that is the Australian drilling industry.

To find the reasons behind this issue, some decision makers were asked about the reasons why we are not utilising the innovative technologies in the Australian drilling industry. The answer was, “What we have got works fine

---

11 This specific technology’s name cannot be mentioned as the participant could be identified

and answers the purpose. We do not need to employ an innovative technology with no proven record of efficiency." Another participant stated that, "Utilisation of any technological or non-technological innovation can be risky and no one wants to be responsible for a possible failure. This is why we are a quick follower but not necessarily a pioneer." In contrast, since the Australian oil and gas industry is comparatively young, to find a technology with a proven record of efficiency in Australia might be a tough challenge.

Another interesting answer was that, "If a technological or non-technological innovation works fine somewhere in the world, it does not necessarily mean it will work well here, or it does not mean we need it here. What we have got is quite up to date and works fine."

A leader from a local drilling company explained the definition of innovation in Australian drilling in a more clarifying way. According to this participant, most innovations are either related to safety procedures or operational procedures. He also mentioned that most of what is so-called "technological innovation" in Australia is purely a modification of an existing technology to either comply with the Australian rules or to make things safer. So, there is no strong record of "new to the market" sort of innovation. Generally, according to this participant, innovation and R&D becomes priority only if it is the client company's requirement.

This point is also supported by the data obtained from one of the survey questions, when participants were asked about the number of innovations deployed within the past twelve months for which their unit played a leading role. Perhaps unsurprisingly, 77% of innovations were related to processes, policies and generally non-technological innovations and only 33% were product-related (Figure 4.1).

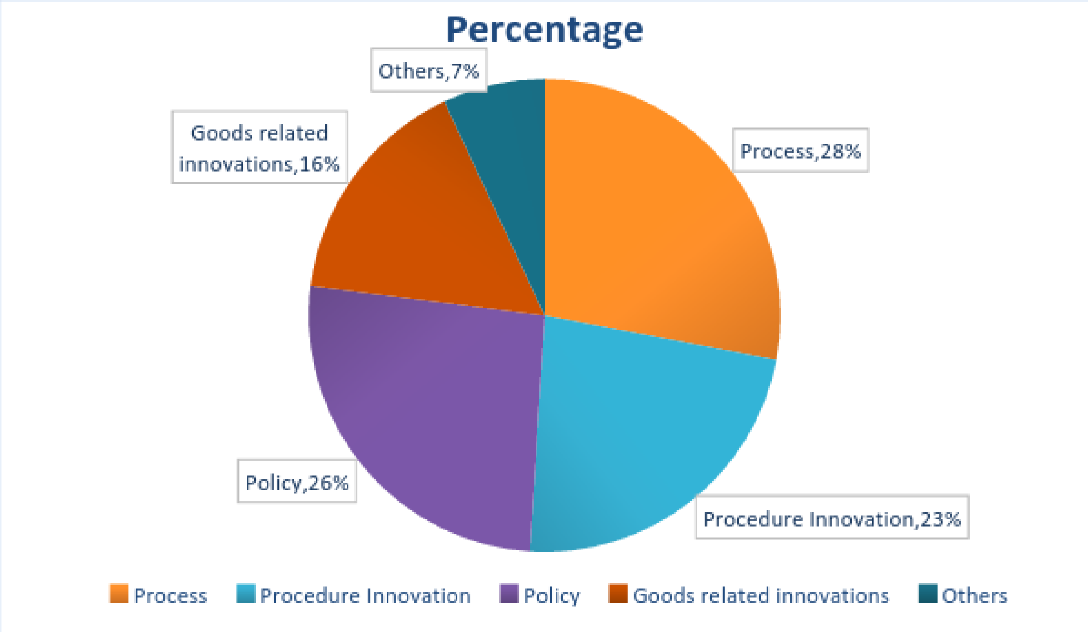


Figure 4.1: Number of innovations deployed within the past 12 months

Regardless, the majority of participants agreed that the culture of innovation and specifically R&D in their department and even in the entire company is very weak. Either the nature of Coal Seam Gas drilling does not require much technological innovation, or this is purely an excuse to cover for the lack of R&D in this sector. Most participants agreed that the culture of the industry is "not to make any changes when things are working."

To expand the issue, the participants were asked whether their company would be willing to take a risk in trying to innovate or utilise a technological or non-technological innovation, if the program were supported by government programs (such as innovation funding or a considerable tax exemption). 100% of the participants answered, Yes. The survey indicates that 72% of participants reported that their company does not directly or indirectly receive any support for innovation from the government, while their company policies dictate risk minimisation strategies (Figure 4.2).

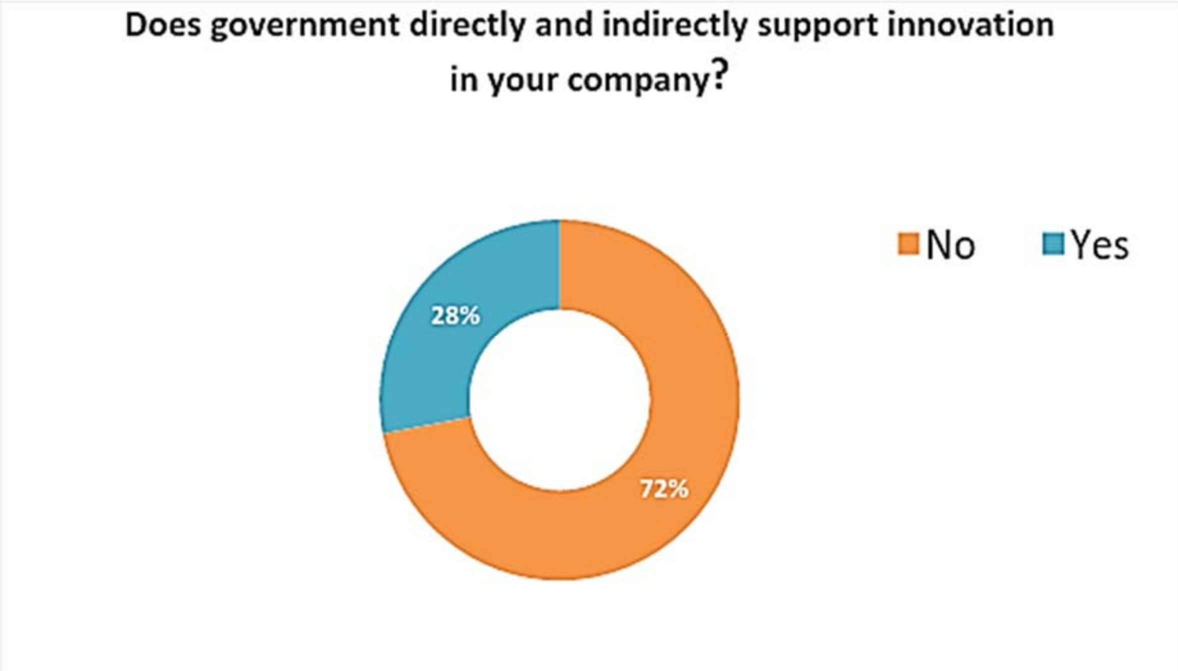


Figure 4.2: Government support of innovation

Another issue that the participants addressed was a lack of provision from the supporting industries. While the operating companies are striving to comply with the Australian rules and regulations of importing new technologies, difficulties in finding the necessary support and services is another discouraging issue.

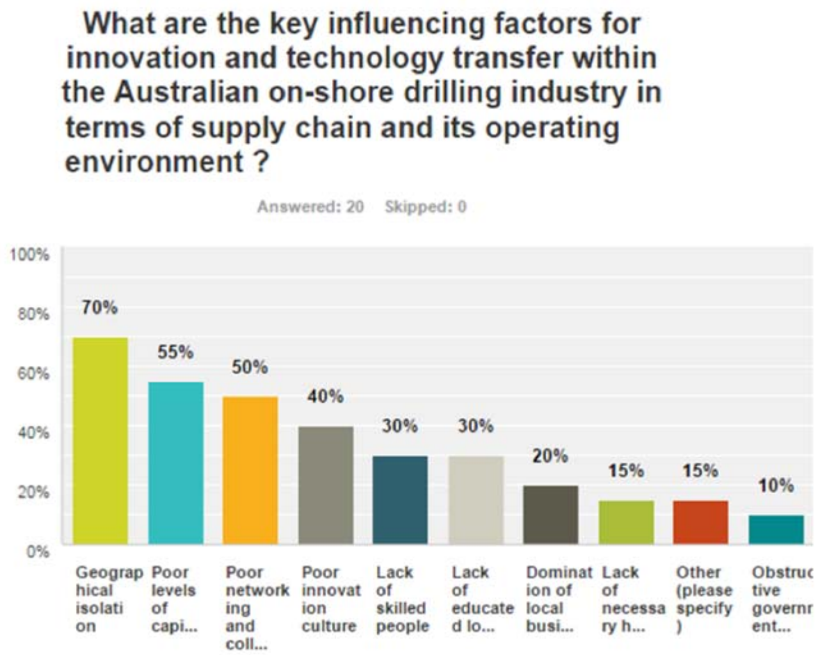
4.4 Key Influencing Factors for Innovation and Technology Transfer

Table 4.1: Key influencing factors for innovation and technology transfer

What are the key influencing factors for innovation and technology transfer within the Australian onshore drilling industry in terms of supply chain and its operating environment?

Answer Options	Response Percent
Poor networking and collaboration	50%
Poor levels of capital investment in innovation R&D	55%
Obstructive government policies and poor government procurement of innovation	10%
Geographical isolation	70%
Domination of local businesses which are seeking local competitive advantage rather than pushing the innovation frontiers	20%
Poor innovation culture	40%
Lack of skilled people	30%
Lack of educated local people	30%
Lack of necessary high-level technologies	15%
Other (please specify)	15%

As the above table indicates, 70% of the participants from the drilling sector of the Australian oil and gas industry stated that the geographical isolation of Australia was the biggest barrier to innovation and technology transfer. Interviews of ten participants showed that by creating a more attractive environment for technology owners and advanced operators, we can overcome the geographical disadvantage.



Answer Choices	Responses	
Geographical isolation	70%	14
Poor levels of capital investment in innovation R&D	55%	11
Poor networking and collaboration	50%	10
Poor innovation culture	40%	8
Lack of skilled people	30%	6
Lack of educated local people	30%	6
Domination of local businesses which are seeking local competitive advantage rather than pushing the innovation frontiers	20%	4
Lack of necessary high level technologies	15%	3
Other (please specify) Responses	15%	3
Obstructive government policies and poor government procurement of innovation	10%	2
Total Respondents: 20		

Figure 4.3: Key influencing factors for innovation and technology transfer

4.4.1 Concept of Innovation and Culture of R&D

As mentioned earlier, a significant barrier to innovation is the poor level of capital investment in innovation R&D. Speaking to one of the key industry leaders indicated that due to the poor culture of innovation, R&D budgets are either never enough or the R&D projects are being put on hold in favour of operation projects. Another participant stated that R&D is being looked at as a cost rather than an investment, while other projects are being viewed as fund-generating processes. However, the survey indicates that 17% of the firms spend between $1000 and $50,000 on innovation-related activities and only 22% spend more than $1,000,000 per annum on innovation (Figure 4.4).

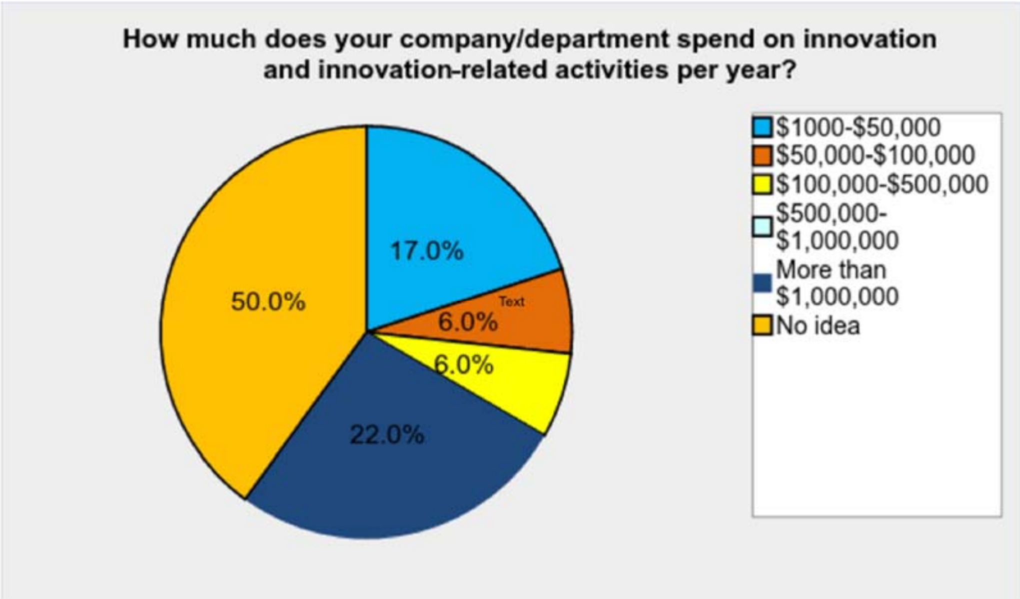


Figure 4.4: Innovation investment in the relevant department

This again can be related to the poor culture of innovation and lack of knowledge of the concept of innovation and technology transfer. Since this matter was brought up in the survey, the concern about the culture of innovation was directed towards the person in charge of innovation to see why the culture of innovation has not been promoted properly to educate the firm about the advantages of R&D.

The answer to this question was that 50% of survey participants specified that they do not have anyone in charge of innovation in their company. Interviewing the leaders from companies with someone in charge of innovation identified that most people in charge of innovation are either from a different background who do not necessarily have the knowledge of the R&D concept or they are employees with other responsibilities who happened to be given the task of R&D and innovation on top of their current projects.

It has been said by participants that most R&D people have an operational background and are traditionally only after short-term results, while R&D requires a long-term vision. This might be the reason that only 22% of participants think having someone in charge of innovation is an effective factor in having more innovation in their firm. In addition, it seems that most companies practise innovation through workshops, regular gatherings and problem solving but only 6% of companies have a reward system to support innovation opportunities and 61% do not even have a proper method of measuring the result of innovation plans such as effects, outcomes and motives at all stages of the process (Figure 4.5).

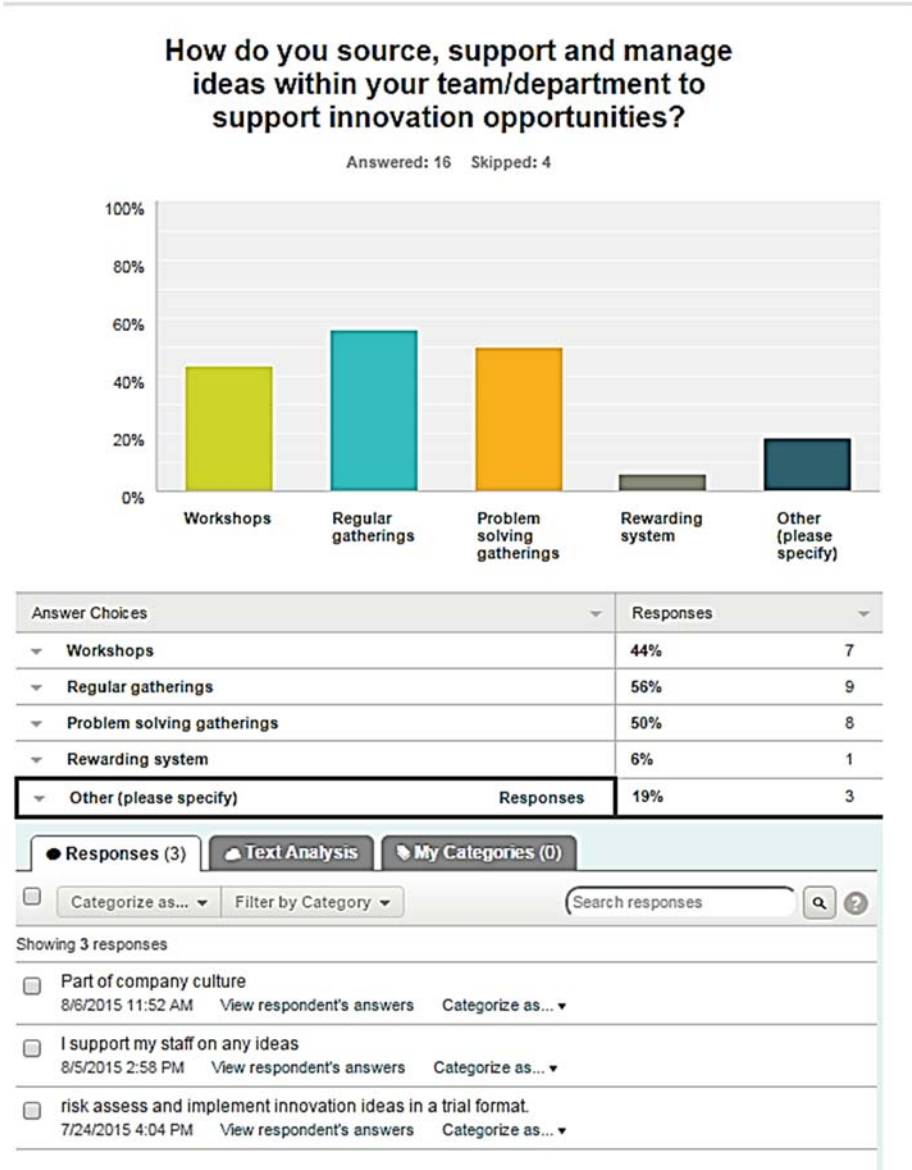


Figure 4.5: Source, support and manage ideas within the team/department to support innovation opportunities

67% of participants stated that the concept of innovation is not clearly covered by their company policies. The surveyed participants indicated that the lack of awareness of alternative strategies and technologies and poor perceived Return On Investment (ROI) are key influencing factors for the innovation and technology transfer within the Queensland onshore drilling industry in terms of the supply chain and its operating environment.

Interestingly, although the Australian Government report (2014) depicted obstructive government policies and poor government innovation procurement as being a barrier to Australian innovation, it seems that none of the participants knew that this factor was a barrier in the drilling industry. The researcher looked at the level of collaboration between companies with drilling projects in Australia and local/international sources.

Only 53% percent of the companies said they have collaborations with an overseas company. Out of this 53%, 38% have a high level of collaboration and 50% stated that they have some sort of collaboration while 12% have a weak level of collaboration. As a substantial portion of the interviewees were from multinational companies, this figure might not be the most accurate indication of the Australian drilling industry’s international collaboration. As a result, interviewing the participants from the IOCs showed that the majority of companies with a high level of international collaboration are multinational companies with an integrated sharing policy.

Remarkably, 80% of companies quantified that they have a moderate level of collaboration with local companies. The interview results show that the majority of local collaborations are about safety polices and not necessarily technological innovation or knowledge sharing. This is a good benchmark to the lack of networking and collaboration of the Australian drilling industry within the sector as well as globally. It seems that competition and perceived commercial barriers has had an isolation effect that collaboration is weak and no longer considered as an advantage. Also, since Australia has a young oil and gas industry, the government might not have the necessary experience in encouraging policies to promote collaboration.

One of the interview participants who is in charge of a technology department mentioned that the lack of familiarity with the nature of the oil and gas drilling industry within the government sector is the main reason behind the lack of encouraging policies. While confirming the same fact, another participant added that the government’s model for the oil and gas industry and especially the drilling industry is not complete and the government is seeking help from project owner companies to help develop and complete the model. Remarkably, this is not the only incomplete task in supporting the oil and gas industry. As another participant stated, the boom of CSG happened so quickly that the government was not ready to support and provide the necessary models, assets and infrastructures for the oil and gas industry.

Therefore, the entire budget has been spent on building quickly in order to catch up with the boom, with no fund allocation to R&D. This is why some might believe that the budget on the construction of the oil and gas industry in Australia was not managed properly. Also, some might argue that more budget should have been allocated for R&D and studying the changes and strategies, rather than overspending on quick building of infrastructure to support operations. In order to clarify the matter precisely, Section 4.4.2 highlights the interview answers provided by selected participants for further clarification on identifying the barriers.

4.4.2 Interview Questions

After performing the survey, the data identified the key barriers and the influencing factors to the innovation and technology transfer in the Australian drilling industry. The four questions below were designed after the survey of twenty leaders in order to clarify the collected data and evaluate the findings.

The government report of 2014 on Australian innovation shows that there is a poor collaboration record between Australian industry sectors (including the drilling sector). Why is this?

A numbers of reasons have been mentioned about why collaboration is limited between sectors. As stated previously, the participants were given the opportunity to provide as much detail as they wanted as long as the conversation remained within the specified framework. Nonetheless, the fundamentals declared were:

- A culture of isolation or “doing it alone” (especially drilling): The abovementioned fact is a tangible issue observed by the researcher himself during his work within the Australian drilling industry. The culture of isolation comes from the culture of independent attitudes/isolated thinking. Not asking for help and not asking to know more seems to be an established culture within the Australian drilling industry. Referring to the abovementioned fact that for most R&D people, most managers and senior managers come from the operations side, this culture can be promoted throughout the industry. Therefore, while collaboration is not being practised by individuals, the culture of collaboration is not being promoted within the company either.

- Lack of understanding in regards to the commercial aspects: As stated earlier, drilling operations do not like long-term vision or long-term commercial plans. Drilling operations are more about getting the job done with what has been working before. Looking into collaboration between sectors, local and international companies requires a deep understanding of long-term commercial planning.

- A lack of top-down encouragement, of ‘how can we do this better’ and the cultural attitude of ‘this is how it has always been done’. While collaboration is about learning and sharing new things and doing things in a different and possibly a better way, drilling operations seem to be relying on what they already know best and not seeing the necessity of learning or sharing anything else.

- Extremely competitive margins due to overcapacity and lack of funds directed to exploring collaboration and innovation.

- Most innovations are protected for competitive advantages. Therefore there will be no sharing and collaboration scheme.

- Most drilling companies are not Australian and policies are being dictated from their headquarters, which are located overseas. Most of the time the policies are not even being changed to match the Australian environment. Therefore, there will be no collaboration between firms due to competitive advantages.

The next question to identify the barriers was: ***Why do these barriers exist?***

The answer was that the Australian drilling industry has gone through a period of massive growth due to the fledgling CSG industry. Throughout this period, there has been a tremendous strain on all resources in both the contractor and the operator camp, which has been further compounded by tight timeframes. For the contractors during this period, there was a culture of “just keeping up with demand and compliance” due to the industry moving at such a pace where a culture of “ticking the box “was commonplace. When contractors were busy meeting the industry requirements, proponents and macro events such as oil price fluctuation resulted in retrenchments and a severe contraction within the industry.

The cultural aspects are also a significant determinant in regards to collaboration and the resulting innovation. This has developed from the more mature oil fields around the world and is also company specific, whereby it is a systemic culture which is difficult to change. One of the most significantly declared facts was that, “There is no party to bring unity between sectors. Everyone is just trying to get the job done as the whole boom happened too fast. Australia was not ready for such a fast-paced industry.” This is one of the reasons that some participants declared that Australia was not ready for such a fast-paced industry in such a short time, which was caused by demand for CSG.

Beyond the scope of these factors, it was important to know if the participants had tried to be innovative or if they had attempted introducing a specific technology to the drilling sector. Consequently, the following question arose next: ***What kind of innovation do you wish you could have done?***

Some interesting examples provided were:

- The creation of situation-based training incorporating state-of-the-art simulators to train and expose individuals and entire teams to drilling emergencies. This has been demonstrated to be more relevant to the oilfield than the generic individualist style of classroom training.
- A new method of directional drilling.
- Using a specific drilling fluid which enables a better quality drilling operation.

For these specific mentioned innovations, participants were asked to address the barriers stopping the establishment of their ideas with the question***: What are the reasons you could not achieve them?***

- Achieving the economy of scales is difficult as the number of projects compared with other places in the world is low.
- In order to get support and approval from the government, the idea needs to be shared with the government; otherwise there will be no support. The company is not willing to share the idea for competitive advantages. This is where the idea is stopped from developing.
- Australian project owners do not see the value in owning technologies, unlike some IOCs and NOCs.

4.5 Focus Group Comments

Speaking to the focus group in order to validate the findings and data collected narrowed the analysis and the conclusion of the paper. The findings were presented to the focus group to find out their opinion about the collected data. Remarkably, the participants agreed on the mentioned facts. One of the participants with years of global oil and gas experience as well as a high-level academic background mentioned that the issues of innovation and technology transfer is a global challenge for the oil and gas industry and not only in Australia. However, the Australian oil and gas industry is mentioned to be a young, small industry compared with the global oil and gas industry. Australia chooses and adopts models from international sources. He added that it is hard to achieve the economy of scale in Australia and hard to try a new technology due to the industry’s size in Australia. Therefore, it is common to develop and promote a technology or an innovation pattern in the USA or Canada and export it to Australia. Consequently, suppliers of technologies offer what they have been asked for and not necessarily the latest technologies.

Another participant, while confirming the same facts, indicated that this is not necessarily an unacceptable standard for Australian drilling. Australia does not have the manpower and the technology to be the exporter of the innovation models and latest technologies to the world. Participants have explained about other countries such as Singapore, South Korea and Japan as the example of innovative countries with similar situations. One of the participants, while acknowledging the fact, said that Australia cannot be compared to any of the mentioned innovative countries because of its size. A city or a zone can be compared such as Darwin and Singapore (mentioned by the researcher) but some might still disagree with this comparison. However, all participants mentioned that this is not an excuse for the current innovation pattern in the Australian drilling industry. They added that the Australian drilling industry has just started looking at innovation and technologies in the energy sector and Australian drilling is behind the global market. This sector requires government support as Australian drilling companies cannot afford the risk of innovation.

Participants were asked about their opinion on the future of innovation in Australian drilling. It was strongly suggested that the Australian Government needs to strongly offer motivational innovation programs such as heavy tax exemptions or reasonable-size project funding for companies to afford the risk. According to the participants of the focus group, Australia has the potential of not only being the deployer of the latest technology but to be the exporter of innovation and technology to the global drilling industry.

4.6 Summary

The initial hypothesis derived from the literature review suggested that the Australian drilling industry does not employ the latest technologies and innovations. In contrast, the answers from the industry participants indicated that the Australian drilling industry is indeed utilising the latest technologies. This has uncovered a research gap and a blind spot in the findings. As a result, the researcher attended two international exhibitions/conferences to investigate matter. Further research indicated that although the available technologies in Australia are relatively up to date, they are not necessarily the most efficient or innovative technologies. Hence, the contrast between the literature review and the survey appeared to uncover a gap in the research. Interviewing distinguished renowned industry leaders and experts added significant value to the findings. It seems that the Australian oil and gas sector does not provide an attractive ground for technology competition.

One of the most significant facts mentioned by the same participants was that there are no advanced technologies that cannot be brought to Australia if the economy of scale can be achieved. The main barrier to achieving the economy of scale mentioned by the participants was the lack of support from third party contractors, the size of the country when compared with the size of the projects and lack of security for continuity for the project compared with the heavy amount of investment required for entering the Australian market.

Above all, the research has found that amongst all the discovered internal barriers to innovation in the Australian drilling industry, the lack of government support for R&D purposes is the most significant factor.

CHAPTER 5: RESEARCH FINDINGS

5.1 Introduction

This chapter covers a comprehensive description of the research findings based on the data triangulations, individual observations and reflections as well the generalisation method. The researcher also utilised personal reflections, which include ten years of observations, to form the initial questions and the hypothesis. During the literature review study, the questions were confirmed to address the appropriate issue (barriers to innovation and technology transfer). During the course of the surveys and interviews, the research questions identified a blind spot in the study through observation. These collected data approaches are aimed at exploring and explaining different issues associated with the research questions:

- To what extent does the Australian onshore drilling industry utilise the latest technological innovations?

- What are the key influencing factors for innovation and technology transfer within the Australian onshore drilling industry in terms of the supply chain and its operating environment?

- How do the key influencing factors create and promote barriers to innovation and technology transfer?

- To what extent do the barriers influence innovation and technology transfer?

5.2 Analysis and Data Triangulations

The triangulation method is a way of ensuring the validity of the research data and findings by examining the same topic from different sources. The idea of triangulation is to investigate the same phenomenon from diverse angles, rather than cross-validating the experience (Kielmann, Cataldo & Seeley

2012). The researcher used triangulation analysis in qualitative research to check the final results' validity, reliability and consistency of the collected information, as explained in Chapter 3.

The triangulation analysis was achieved by reviewing the results five times and comparing the results. The consistency of the collected data and the generated findings were examined from different sources. The researcher's observation from three years of working within the operations sector of the Australian onshore drilling industry from drilling operations to office, as well as over ten years of working for different faculties of the international oil and gas industry, enabled him to observe and gather data in the form of a journal and notes.

5.3 Generalisation and Overall Findings

The strategic and methodological approach chosen in this research is not to prove or dictate any point but to achieve an in-depth understanding of the innovation and technology transfer of the Australian drilling industry in order to identify the barriers. The overall findings are purely to address the technology gap and the cause of the barriers. Below is a detailed explanation of the research questions:

Question 1:
To what extent does the Australian onshore drilling industry utilise the latest technological innovations?

The initial research and findings, based on the gathered data, suggested the hypothesis that the Australian drilling industry does not fully utilise the latest technologies. This proposition was found to be quite accurate. Although some advanced drilling machinery has been introduced by international contractors to the Australian drilling industry, local industries were not willing to support and cope with these technologies because they were not practising the use of the latest technologies.

Although the international onshore drilling companies use high-tech drilling machinery and equipment such as coil drilling rigs or cyber chair rigs, they face difficulties finding local supporting businesses in Australia who are capable of providing equipment. For instance, there is no company with the capability of re-wrapping a coil drilling reel in Australia. Hence, the companies using this technology have to rely on their international suppliers in Singapore or Houston for equipment maintenance.

Maintenance of other technologies such as the on-site drill collar repair, which is a simple procedure in the USA and Canada, might not be practical in Australia. This means that most supporting sectors are not fully utilising the latest technologies. The consequence of this issue is that some latest technologies cannot be transferred to and utilised in Australia. This thesis also recognises the lack of motivation of local businesses to adopt and learn new technologies as a highly contributing factor to the barriers.

Question 2:

What are the key influencing factors for innovation and technology transfer within the Australian onshore drilling industry in terms of the supply chain and its operating environment?

The initial studies suggested the lack of government supporting policies, poor government procurement of innovation and the industry's current weak innovation culture to be the main influencing factors. Another essential factor to note is the negligence of R&D innovation performance by Australian firms. As a result, poor networking and collaborative efforts, lack of local skilled and educated professionals and poor manufacturing industry seem to be the most frequently mentioned issues. These propositions were found to be partly correct.

The Australian Government and the Australian drilling industry do not appear to be open to adopting new technologies and knowledge from overseas. This trend is contributed to by local businesses, or the government, or both. It affects the innovation system of Australia. The geographical position of Australia was a possible factor but examples of countries who overcame this barrier rejected the geographical position as being a key influencing factor.

Question 3:

How do the key influencing factors create and promote barriers to innovation and technology transfer?

As mentioned earlier, each of the identified key factors either creates or contributes to the technology and innovation gap between Australia's drilling industry and the global market. Poor collaboration between the Australian drilling industry and foreign technology owners not only slows down the technology transfer process but also causes a lack of competition, which weakens the innovation culture over time. Therefore, local businesses with local competitive advantage fail to improve their processes and encourage innovation.

Higher education and skill development are being neglected and, instead, short-term courses are being used for career development purposes and not for the significant improvement of the industry, to compete and adopt international technology and innovation ideas. The reports and empirical evidence suggested that the lack of government supporting policies and the industry's current innovation culture to be the main diminishing factors.

Existing barriers through quotas and tariffs to support local business are also mentioned as a discouraging factor for the big players of the drilling industry to bring their “A” game to Australia. The lack of local skilled and educated workforce as well as a poor manufacturing industry seem to be the most reported issues by key industry players. Surprisingly, Australia's geographical position on its own does not seem to be a key influencing factor, if there is sufficient backing from the local manufacturing and local high-tech workshops being supported by a highly skilled and educated work force.

Seemingly, the geographical position of Australia is a disadvantage only because most technology and knowledge sources are not available locally.

Geographical position however was seen to be a disadvantage. Examples of countries such as Singapore, South Korea and Japan, who overcame this barrier, rejected geographical position as being a key influencing factor. All of the mentioned factors are found to significantly contribute to Australia's low global rank amongst other advanced countries.

The Australian Government and the Australian drilling industry seem not to be adopting and open to new technologies from overseas. This trend is contributed to by either local businesses or government or both, thus affecting the supply chain of the innovation system of Australia.

Question 4:

To what extent do the barriers influence the innovation and technology transfer process?

To answer all four questions accurately, the researcher studied and referred to a few accredited global indexes such as the OECD Better Life Index, the Global Innovation Index, etc, to compare Australia's current innovation and technology transfer position with other advanced countries. Australia has been compared in different areas such as R&D, government support, local workforce and innovation culture.

The result showed Australia as a poorly-performing country in terms of innovation. However, in some areas of the Australian drilling industry, such as foreign direct investment, Australian mining appears to be performing better than other sectors. In the majority of cases, Australia is not one of the five top-performing countries in terms of innovation.

To answer the key questions, each of the factors and indicators that affect the technology transfer and innovation were investigated separately. The qualitative and quantitative data collection indicated that poor government policy regarding innovation and lack of local educated and skilled people are the most significant barriers to innovation and technology transfer in the Australian drilling industry.

Although other factors such as poor collaboration, poor innovative culture and lack of investment in R&D are recognised as essential barriers, a strategic and well-planned government policy could reduce these barriers and ultimately change the culture of the industry. The collaboration between different sectors of the industries, research institutions, universities and the industry needs to be strategised, planned and encouraged.

5.4 Reflection: Author’s Notes and Journals

As part of the researcher’s journey of finding answers for his research, he carefully kept record of all his observations during his work within the Australian drilling industry, as well as referring to his notes from years of consultancy. As a result, his recorded personal notes and journals have turned into a source of data to reinforce the validity and reliability of the findings.

The data, findings and suggestions in this paper are the result of the author’s years of working within the oil and gas industry. Twelve-hour day/night shifts on fly in/fly out drilling operation rosters is how far the researcher went to find the answers. It is important to mention that the qualitative data are not merely a diary or life stories but a representation of the real world and the industry’s specific problems, which enable researchers to provide practical solutions.

Nonetheless, new findings required the researcher to constantly evaluate, analyse and question his findings. The constant adjustment of the results, which were based on the new beneficial outcomes, was a joyful and at the same time exhausting challenge for the researcher. Table 5.1 outlines the reflection of these notes and journal records during three years of working within the Australian onshore drilling industry and business development consultancy in Asia.

Table 5.1: Reflections of Author's Notes and Journals

Engagement Phases	Reflections
Building Trust	This period was what the researcher named the "Fit-in or fly-off" period where the researcher experienced an intensive culture shock. Learning the machines, studying the culture of the industry and examining the utilised level of technology transfer and innovation was possible only if the researcher could observe and ask, and that could happen only through building trust. According to the researcher's experience, one of the most significant characteristics of the drilling industry in Australia is that the newcomers have to earn respect through hard work and sacrifice. Hard work and sacrifice have their own definitions on the rigs. As the researcher could not risk the integrity of the information, working on the rig floors and being a part of the operation team was a necessity. Building trust and giving industry people a reason to share their knowledge was the biggest challenge for the researcher. The researcher had accepted the challenge and his journey on the rigs took him about three years.
Sharing and Learning	The barrier of earning trust was gradually broken within a few months, significantly earlier than overcoming the barrier of needing to earn respect. The researcher was trusted to learn and perform works but he still needed to prove his abilities and dedication through hard work and sacrifice. This is where client companies' representatives, industry leaders and drilling supervisors with over ten years of experience started sharing their knowledge with the researcher. As the heavily experienced leaders, who had operated with different systems overseas, began to express their dissatisfaction with the differences, the researcher started observing and taking notes of these differences. The most reported complaints by all parties were the overprotective regulations, as well as poor supply chain and logistics, poor procurement and lack of available technologies. Every time a leader gave an example of a technology which is not available in Australia, the researcher took a note of that.
Ask and You Shall Receive	The rewarding stage was when relationships were built and the researcher had attained enough trust and respect to be requesting more in-depth information from the leaders. At this stage more knowledge of the industry and what has been utilised, the difference between different operation environments of different countries and the differences in procedures were shared. Therefore, the researcher could learn the outcome of different procedures. A very interesting case of innovation was the motivation, rewards system and performance evaluation system of the very large oil and gas companies and how effective the system was to encourage innovation. Another significant concern shared was the availability of machines and high-technology equipment which do not exist in Australia and how much difference this high-technology equipment can make in the operational procedure.

Below are the answers based on the researcher's ten years of observation, taking notes and thinking during his employment within the Australian drilling industry:

Question 1:

To what extent does the Australian onshore drilling industry utilise the latest technological innovations?

During the researcher's employment within the Australian drilling industry and, specifically, as the maintenance planner, job duties involved employing the latest technologies. Often, he had to outsource the maintenance, repair and servicing of the equipment to overseas companies. Furthermore, most of the time senior management reported a lack of availability and frequently commented on the price differences of such services in the North America. This is only a fraction of the difficulties a drilling contractor faces in Australia, caused by lack of available sources.

The most significant observed fact was that most local supporting businesses were not even aware of such existing technologies. Furthermore, if it were any firm with such machinery, they would create a monopoly (normally with astronomic prices) to avoid any local or international competitors entering the market. This sort of action would discourage other firms from becoming involved in employing the latest technology transfer.

Although most companies are not against innovation, they do not encourage it. In simple language, industry leaders will hear out the new ideas, but most leaders do not create a specific pattern or model to induce innovation.

In addition, some might agree that the priority is to get the job done in the operational environment. Thus, if the innovation is not safety related, it will either be postponed or it does not generally receive the attention it might deserve. A very similar scenario happens to R&D budgets. If it is not about the operation, it can wait.

Question 2:

What are the key influencing factors for innovation and technology transfer within the Australian onshore drilling industry in terms of the supply chain and its operating environment?

The researcher's observation indicates that the current culture of the industry is the main reason behind the barriers to innovation and technology transfer. The cultures of "We have been doing this for a long time, why do we need something different," or "This is working well, why do we need something different," seem to the researcher to be the main barriers to innovation and technology transfer.

On the other hand, as the old saying goes, "everything comes from the top down": if the government does not promote more innovation and the employment of the latest technologies, the project owners do not demand such things from the operation contractors either. As a result, the whole industry operates on this myth that we already have the best and the latest technologies in hand.

However, in the case that a drilling company was demanding more support from third-party contractors, lack of knowledge and facilities were identified as another discouraging factor for bringing in the latest technologies by the drilling contractors.

Question 3:

How do the key influencing factors create and promote barriers to innovation and technology transfer?

As mentioned above, when there is no request for anything new either technologically or non-technologically, as well as other discouraging factors, the drilling industry stays where it has been before. Lack of eagerness and motivation to improve and do things better could result in the Australian drilling industry staying behind the global market. The researcher noted that the drilling personnel, regardless of their ranking, have always been encouraged to come up with innovation regarding safety rather than other types of technological and non-technological innovations.

A significant point to address is that the researcher has no intention of questioning the current methods or technologies which are being used in the Australian drilling industry. Seeing the industry not being open to something new is what the paper is addressing. Another identified barrier due to the culture of the industry is the lack of manufacturing and fabrication in Australia, which appears to be another discouraging factor.

Question 4:

To what extent do the barriers influence innovation and technology transfer?

The researcher has directly observed a couple of drilling contractors' struggles and difficulties in coping with the lack of availability of modern technologies. Where the manufacturing and fabrication are quite weak, innovation may not be as robust: if any technical idea is suggested, it stays at the theoretical level. In an environment where competition is stronger than cooperation, sectors, industry and research institutions do not connect.

Consequently, the drilling sector will just be busy getting the job done, without any extra effort to look around for something new or sometimes even to think about something new. This might be one of the reasons that the Australian drilling industry might not be the most attractive option for the big oil and gas players. Whether this culture is inherited from other international companies entering Australia or it is a part of Australian culture or caused by an extremely quick Coal Seam Gas boom with no preparation, it exists and needs to be addressed.

5.5 Observation During Data Collection: Interview and Conference

The survey answers (Appendix 5) developed a series of new questions to help to identify the barriers. Interviews were performed at the most convenient place, such as the participant’s office or a coffee shop close to their workplace.

In cases where the participants were geographically remote, the interviews were conducted via teleconference. The survey results were presented to the interviewees to get more accurate answers to the designed questions. In the roughly 30 minutes per interview with the participants, much information was received for further analysis.

One of the most interesting factors was that the participants with experience of working outside Australia showed signs of frustration with the lack of available support and technologies, while the participants who were very involved with the local industry claimed that the most advanced innovations and inventions are available in Australia. As a result, a blind spot was identified between the literature review and the data collected during the interviews. For example, why were the local Australian oil and gas people claiming to utilise the latest technologies while the international sources were saying otherwise?

The questions were taken to the 2017 Asia Pacific Oil and Gas Conference and Exhibition (APOGCE) in Bali, where most oil and gas companies in the Asia Pacific (including Australia) participate to share technology and knowledge. The researcher interviewed an operations vice president, an operations director and other executives of the oil and gas industry. Most interviews were conducted at the exhibition stands or during conferences.

One significant finding was that although APOGCE is an event which is presented in Australia every other year, there was no tangible presence of Australian companies at the event. This is where the questions of Australia’s international presence at the technology events have been raised. A remarkable rhetorical question by one of the senior executive to address the same issue was, “Where are the Australian companies in the exhibition?”

The same approach was taken by the researcher in the Middle East at the 2015 International Conference and Expo on Oil and Gas in Dubai. Very similar answers and results were given by the participants. Curiosity made the researcher take the questions to a few candidates in North America and Europe. The summary of findings from the interviews is explained below.

Question 1:

To what extent does the Australian onshore drilling industry utilise the latest technological innovations?

The proposition that the Australian drilling industry does not utilise the latest technological innovations is partially correct. Many sectors of the industry utilise the latest technology to some extent, according to data collected in this research. Hence, policies need to be made in a way that encourage the utilisation of the latest technological innovations for improvement, to help the industry in minimising the risk of failure and testing new approaches.

Australia has untouched reservoirs of oil and gas according to the literature review. Extracting these resources in the most efficient way requires proper innovation and technology transfer policies for the future of the Australian energy sector and especially the drilling industry.

Question 2:

What are the key influencing factors for innovation and technology transfer within the Australian onshore drilling industry in terms of the supply chain and its operating environment?

The main barriers preventing innovation and technology transfer are poor networking and collaboration at both the local and international level, poor levels of capital investment in innovation R&D, obstructive government policies and poor government procurement of innovation and domination of local businesses which are seeking the local competitive advantage rather than pushing the innovation frontiers.

Poor innovative culture, lack of local skilled personnel, lack of educated professionals and lack of necessary high-level technologies seem to be the secondary but still vital barriers to innovation. However, Australia's geographical isolation has also been identified as a barrier which indirectly contributes to increasing the impact of the barriers to innovation.

Question 3:

How do the key influencing factors create and promote barriers to innovation and technology transfer?

To some extent, each of the identified key factors either creates or contributes to the technology and innovation gap between Australia's drilling industry and the global market. These key factors and the cultural gap raise the barriers even higher. Poor collaboration between the Australian drilling industry and foreign technology owners not only slows down the technology transfer process, but also causes a lack of competition because of the way that the innovation culture has been weakened over time.

This has unnecessarily given the domination power to the local businesses to seek the short-term competitive advantage rather than pushing the innovation frontiers for better long-term results. Therefore, the results suggest that the local workforce is not motivated by a perceived need for higher education and skill development, to compete and adopt international technology and innovation ideas.

Question 4:

To what extent do the barriers influences innovation and technology transfer?

To answer this question, the researcher studied and referred to a few accredited global indexes to compare Australia's current innovation and technology transfer position with other advanced countries. Australia was compared in different areas such as R&D, government support, local workforce, etc.

The results indicated Australia's innovation performance overall to be poor. Nevertheless, in some areas such as financial investment in R&D, the mining industry, including the drilling industry, seems to be performing better than other sectors. However, in most indexes, Australia is not mentioned as one of the five top-performing countries in terms of innovation and, in some cases, it is ranked below international index medians.

5.6 Significant Finding of Note

Interviewing different leaders from different levels of the industry gave an unexpected result that provides a remarkable outcome. Most leaders from project owner companies and multinational companies have stated that innovation plans and R&D budgets are defined in their company's policies.

On the other hand, most servicing companies (which in this case are the drilling companies) did not have a proper strategy in place. When asking the participants from the drilling companies about the reasons for not having a proper plan for innovation strategies, they reported that as it is not a requirement by the client company, they are not concerned about it.

Basically, it seems that innovation occurs only if it is a requirement of the client companies (project owners), such as innovation in safety. This means that client companies somehow dictate the level of innovation in the Australian drilling industry. Also provocative was that there was a considerable contrast between answers collected from leaders of multinational firms and leaders of local firms with no partnership with any overseas company. This indicates a considerable gap between different layers of the pyramid of knowledge. Figure 5.1 is used to visually depict this conceptualisation.

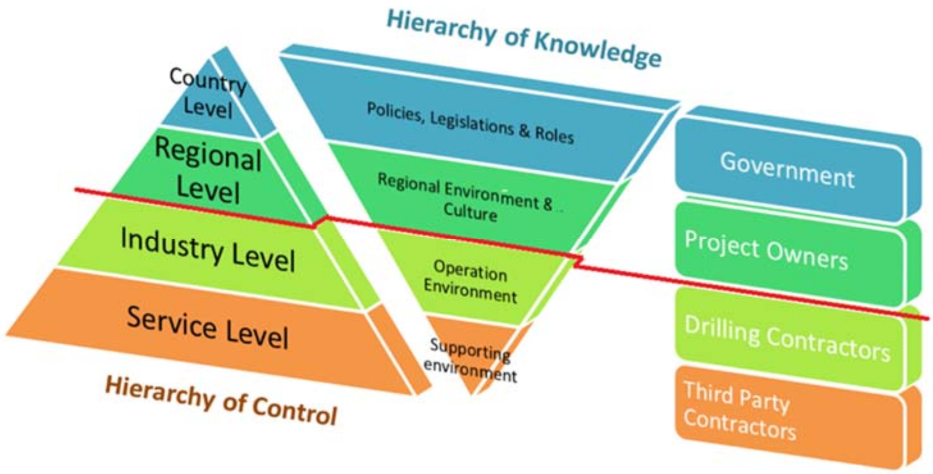


Figure 5.1: Hierarchy of knowledge vs hierarchy of control

As this figure illustrates, the hierarchy of control, which shows the taxonomy of decision-making at the country level, indicates the government as the policy- and rule-maker. Project owner companies such as Santos, QGS, Origin, etc, affect the environment and the culture of the industry at a regional level. The industry level includes the drilling contractors such as Saxon, Savanna, Easternwell, etc, who are directly involved in the drilling operations.

Some may argue that companies such as Schlumberger (Wireline section), GE (Wellhead Control section), and Halliburton (Cementing section) can be counted as the service providers (as they are directly involved in the process of drilling). However, for the purpose of this thesis, they will be at the industry level, alongside the drilling contractors. Consequently, third-party contractors such as inspection companies, coil-wrapping companies and tool and equipment providers, who service the drilling machinery and equipment, are at the service level in the “hierarchy of control”.

The “hierarchy of knowledge” indicates that the decision-making process is coming from a government level down. Therefore, the government dictates the innovation policies as well as technology transfer regulations to the entire country and the industry. Hence, the project owners promote and request the policies to and from the lower levels. If these policies are not clear, up to date, strong enough, do not meet the global standards, or are not being emphasised and expressed enough by the government, the project owners might not look at it as a necessity or requirement from the lower levels.

It appears that one of the only subjects on which all levels of the pyramid collaborate with each other (vertically and horizontally) is safety, which has been identified as a non-technical process innovation. However, the interviews and the survey indicate a vertical integration knowledge transfer gap between the government/project owner levels and the rest of the pyramid, as the red line shows in Figure 5.1.

While the data collection illustrates that project owner companies have a clear innovation system in place, drilling contractors and third-party contractors might not have a similar system in place. Although most participants claimed that their company is always ready to hear new ideas, only the candidates from project owner companies reported that innovation is a part of their company's policy. It is important to note that being ready to hear new ideas is not enough. Innovation requires a proper system in place to encourage and induce innovation. The gap can be identified by comparing the current Australian innovation system with a more innovative country's system.

This is a clear indication of a knowledge gap, which needs to be addressed and rectified. However, going back to the position of Australia in the Global Innovation Index; this might be one of the reasons for Australia's current position, as well as possible weak innovation policies.

CHAPTER 6: CONCLUSION

6.1 Introduction to Conclusion

Innovation plays a vital part and contributes to Australian industries and, specifically, the drilling sector of the oil and gas industry. Concern has been raised during the researcher's work within the Australian drilling industry operations that there were barriers to implementing innovation to the industry. It took the researcher more than five years to find the answers and address the issue properly.

The research has two directions; a qualitative methodology and an analysis of the existing drivers of the innovation system which is being practised in Australia. The literature review investigated the definition and critical elements of innovation and technology transfer in an analytical way. It also addressed the local innovation framework within Australia and the comparative international ranking, as well as identifying the prompting dynamics that drive innovation in the industry. The research hypothesis was prepared and developed in the form of four questions:

Question 1: To what extent does the Australian onshore drilling industry utilise the latest technological innovations?

Question 2: What are the key influencing factors for innovation and technology transfer within the Australian onshore drilling industry in terms of the supply chain and its operating environment?

Question 3: How do the key influencing factors create and promote barriers to innovation and technology transfer?

Question 4: To what extent do the barriers influence innovation and technology transfer?

This research was based on a descriptive case study of the onshore drilling industry in Australia, within an action-based learning and hands-on experience structure. In this case, the researcher was engaged as an active observer and member of the industry, as a consultant, rig crew member and as a team member of operation maintenance for about three years. It took the researcher anothertwo2 years to put together all the evidence and form an appropriate case for the existing barriers. It is important to mention that the blind spot in the research led the author to travel internationally to examine the findings. This thesis utilised structured surveys and semi-structured interview methods to validate, verify and confirm the literature findings.

Innovation and technology transfer, as two essential components, play an imperative role in the global oil and gas industry. This research developed fundamental questions regarding the perceived barriers to innovation and technology transfer and also investigated current methodologies creating or contributing to the existence of these barriers. This paper addresses a significant existing gap within the literature in a detailed, illustrative and constructive way. The literature review study found a research gap in the existing barriers to innovation in the Australian drilling industry. After surveying the industry participants, the discrepancy between the literature review results and the local participants resulted in identifying a blind spot and an unanticipated gap in the existing knowledge of the industry.

As a result, a few hypotheses were developed. The first one was whether the Australian oil and gas industry is utilising the latest technologies. The responses from the local and international survey and interview participants have resulted in an answer. The result of the analysis confirmed that Australia is neither utilising nor innovating the latest technologies in the oil and gas industry. With the comparison of Australian resources to top innovative nations, the researcher is persuading the industry not only to be more innovative, but also to be the exporter of technology to other countries. The possibilities, policy development and implementation of this suggestion are discussed in the 'further work' section for future researchers to pursue.

6.2 Conclusion and Research Applicability

The research used a descriptive case study approach based upon the perception of innovation and technology transfer practice of the Australian onshore drilling industry, through the involvement of the researcher in the oil and gas industry. The case study employed literature, innovation culture, evidence and exploration of the defining values, identifiable obstacles and perceived barriers to innovation and technology transfer, to address the effects and consequences of the existence of the barriers.

These barriers were found to be heavily related to the structure of the innovation system and the industry's innovation culture. Parallel to those, there are other contributing factors such as a lack of educated and local skilled people in the Australian drilling industry. One of the most important facts mentioned was that most barriers can be simply eliminated through appropriate planning. For example, the fact that Australian universities are ranked quite highly in terms of research and quality of education means the major facility for the local workforce to be educated is available locally. The rest includes an appropriate plan to encourage education in the industry, alternatively reforming the university programs to meet the industry's need.

The study showed that while in Australia the definition of innovation is at bargain, the international standards are high enough to keep Australia's ranking at the bottom of the top twenty advanced countries. In addition, the research shows the essential role of government policies and systematic planning in advanced innovation structure and technology transfer processes. Innovation in today's economy is the element of survival. While the majority of Australian firms are not innovative, especially within the drilling industry, which is a very fast-paced sector, the industry misses the chance to adopt, transfer and share the latest technologies and innovation knowledge. The innovation process and technological innovations are neither easy to access, nor shared within the supply chain of the drilling industry. The innovation and technology owners' unwillingness to share this knowledge is also understandable and noteworthy. The study suggests that governmental politics and policies for paving the way to reduce the barriers is something that requires addressing.

It is important to mention that innovation is motivated by efficiency within the firm, but can be encouraged by government policies. The more innovative and internationally involved the firm is, the more advantage the firm will have in the global competitive market. Consequently, the sector and eventually the industry will grow, develop and create a stronger economy and bring more opportunities for the industry and society. However, identifying the barriers and finding ways to rectify the obstacles requires collaboration. The best source of identifying the barriers and developing innovation schemes are research institutions and universities. A linkage between universities and the industry can create direct collaboration and consequently produce faster results. It appears that knowledge is transferred from research institutions and universities to the industry, indirectly through industry associations and consultants. As the collaboration is mutual, research results need to be accessible by industry firms and the industry must develop the relationship with universities and research institutions. Government policies in terms of encouraging and improving the relationship are critical.

6.3 Further Work

Future research should aim at comparing Australian government policies regarding innovation with the top five most innovative countries. In this case, the possibility of reducing or even eliminating the barriers can be investigated. As mentioned previously, there are ways the government can systematically aim to reduce the barriers of technology transfer and help prepare local businesses for global competitors.

There are also ways that the government can encourage firms to be more active in innovation and be more ready to adopt changes and be open to new technologies. The government can pave the way for the industry to go through the necessary cultural change and be more internationalised to not only be the employer of the latest technologies and innovation systems, but to be the exporter and deployer of this advanced knowledge.

List of References

Acha, V & Cusmano, L 2005, ‘Governance and Co-ordination of Distributed Innovation Processes: Patterns of R&D Co-operation in the Upstream Petroleum Industry’, *Economics of Innovation and New Technology*, vol. 14, no. 1-2, pp. 1-21, viewed September 2015, http://dx.doi.org/10.1080/1043859042000228651.

Gehman, Admiral H 2003, *Report of Columbia Accident Investigation Board*, NASA, http://history.nasa.gov/columbia/Troxell/Columbia%20Web%20Site/Documents/Congress/Senate/SEPTEM~1/gehman_statement.html.

Grueber, M, Studt, T, Horowitz, M, Tripp, S, Gillespie, A, Rosenberg, E, McCoy, P & Kuchta, C 2013, ‘2014 Global R&D Funding Forecast’, *Battelle*, viewed December 2015, <https://www.battelle.org/docs/default-source/misc/2014-rd-funding-forecast.pdf?sfvrsn=2 >.

Afuah, A 2012, *Innovation Management: Strategies Implementation and Profits,* Oxford University Press, New York.

Allen, MC 2009, ‘Germany’s National Innovation System’, in *Encyclopedia of Technology and Innovation Management*, Oxford, Blackwell, ch 375-389.

Angeles, R 2005, ‘RFID Technologies: Supply-Chain Applications and Implementation Issues’, *Information Systems Management*, vol. 22, no. 1, pp. 51-65, http://dx.doi.org/10.1201/1078/44912.22.1.20051201/85739.7
.
Australian Bureau of Statistics 2013, *Education and Work, Australia*, Canberra, http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/6227.0Explanatory+Notes1May%202013.

Austrade 2015, *Oil and Gas to Singapore*, http://www.austrade.gov.au/Export/Export-Markets/Countries/Singapore/Industries/Oil-and-gas#.VYZbDzCqpBc .

Australian Bureau of Statistics 2013, *Innovation in Australian Business 2012-13*, http://www.abs.gov.au/ausstats/abs@.nsf/mf/8158.0.

Australian Bureau of Statistics 2014, *Innovation in Australian Business*, Australian Bureau of Statistics, Canberra, viewed 21 Jan 2015, http://www.abs.gov.au/ausstats/abs@.nsf/mf/8158.0.

Australian Bureau of Statistics (Sep) 2016, *Labour Force, Australia*, http://www.abs.gov.au/ausstats/abs@.nsf/mf/6202.0 .

Australian Bureau of Statistics (May) 2016, *Labour Force, Australia,* http://www.abs.gov.au/ausstats/abs@.nsf/mf/6291.0.55.003 .

Australian Bureau of Statistics 2014, *Innovation in Australian Business 2012-13*, http://www.abs.gov.au/ausstats/abs@.nsf/mf/8158.0# .

Australian Department of Industry, 2015, *Australian Petroleum Statistics*, Canberra, http://www.industry.gov.au/Office-of-the-Chief-Economist/Publications/Documents/aps/2015/Australian-Petroleum-Statistics-233-December-2015.pdf.

Australian Government Department of Employment (Labour Market Research and Analysis Branch) 2014, *Industry Outlook: Mining*, Canberra https://cica.org.au/wp-content/uploads/2014-Mining-Industry-Employment-Outlook1.pdf.

Australian Government Productivity Commission 2014, 'PC Productivity Update 2014', https://www.pc.gov.au/research/ongoing/productivity-update/2014

Bagby, JW 1992, 'Public and Industrial Policy Barriers to Independent Vertical Integration: Reflections of Keiretsu', *Working Paper on the Law of Business Organizations*, p. 7.

Bass, C 2012, *The Innovation and Creativity Connection*, viewed 20/10/2014, <http://www.talkmgt.com/blog/2012/05/24/carl-bass-the-innovation-and-creativity-connection-at-c2-mtl/>.

Bell, J, Frater, B, Butterfield, L, Cunningham, S, Dodgson, M, Fox, K, Spurling, T & Webster, E 2014, *The Role of Science, Research and Technology in Lifting Australian Productivity*, http://www.acola.org.au/PDF/SAF04Reports/SAF04%20Role%20of%20SRT%20in%20lifting%20Aus%20Productivity%20FINAL%20REPORT.pdf.

Blaustein, RS 2014, 'Comparative Innovation Strategies and Technology Transfer: U.S. Efforts', *US Department of Energy*, viewed September 2014, http://csis.org/files/attachments/100914_RBlaustein.pdf.

Bloomberg 2014, *Most Innovative Countries 2014,* viewed January 2015 http://images.businessweek.com/bloomberg/pdfs/most_innovative_countries_2014_011714.pdf.

Bozeman, B 2000, 'Technology Transfer and Public Policy: a Review of Research and Theory', pp. 1-3, http://www.sciencedirect.com/science/article/pii/S0048733399000931.

BP Statistical Review 2014, *BP Statistical Review of World Energy*, BPStats, London,https://www.bp.com/content/dam/bp/pdf/Energy-economics/statistical-review-2014/BP-statistical-review-of-world-energy-2014-full-report.pdf.

British Petroleum 2013, *BP Statistical Review of World Energy*, British Petroleum, London, 2013, http://www.bp.com/content/dam/bp/pdf/statistical-review/statistical_review_of_world_energy_2013.pdf.

Brown, J 2015, 'Fueling the Oil and Gas Supply Chain', *Inbound Logistics*, (blog), viewed July 2014, http://www.inboundlogistics.com/cms/article/fueling-the-oil-and-gas-supply-chain/.

Bryman A & Burgess B 1994, *Analyzing Qualitative Data*, First Edition , Routledge, London.

Cachon, GP 2004, 'The Allocation of Inventory Risk in a Supply Chain: Push, Pull, and Advance-Purchase Discount Contracts', *Management Science*, vol. 50, no. 2, pp. 222-38, http://dx.doi.org/10.1287/mnsc.1030.0190.

Chima, CM 2007, 'Supply-Chain Management Issues in the Oil and Gas Industry', *Journal of Business & Economics Research*, vol. 5, no. 6, pp. 28-36.

Chopra, S & Meindl, P 2007, *Supply Chain Management: Strategy, Planning and Operation*, 5th edn, Pearson Prentice Hall, Upper Saddle River, NJ.

Churchill, GA 1999, 'Marketing Research: Methodological Foundations', Fort Worth, TX.

Banker, S 2014a, *Exploiting Unconventional Oil Fields Requires Overcoming Tough Logistics Challenges*, Forbes, viewed January 2015 http://www.forbes.com/sites/stevebanker/2014/01/20/exploiting-unconventional-oil-fields-requires-overcoming-tough-logistics-challenges/.

Banker, S 2014b, *The Upstream Shale Oil Supply Chain*, Forbes, viewed August 2015 http://www.forbes.com/sites/stevebanker/2014/08/08/the-upstream-unconventional-oil-gas-supply-chain/.

ConocoPhillips 2015, *Glossary of Terms Oil and Gas*, http://www.conocophillips.com/investor-relations/company-reports/Documents/PDF/SMID_392-COP-Glossary-of-Terms-External-FINAL-5202013.pdf.

Creswell, JW 2013, *Qualitative Inquiry and Research Design: Choosing Among Five Approaches,* SAGE Publications, California.

Cummins, JG 2005, 'A New Approach to the Valuation of Intangible Capital', in *Measuring Capital in the New Economy*, University of Chicago Press, pp. 47-72.

Davoodian, D & Goh, S 2015, Technology Transfer and Innovation in Oil and Gas Supply Chain, *OMICS International Journal*, *429*.

Davoodian, D & Goh, S, 2016, Comparative Analysis of Australian Innovation and the Tyranny of Distance, Under review for publication at the *Australian Journal of Mechanical Engineering*.

Dutta, S & Lanvin, B (Eds) 2013, *The Global Innovation Index 2013: Local Dynamics of Innovation*, Cornell University, INSEAD, and the World Intellectual Property Organization (WIPO), Geneva, Ithaca, and Fontainebleau,http://www.wipo.int/edocs/pubdocs/en/economics/gii/gii_2013.pdf.

Darwin City Council 2015, *About Darwin*, http://www.darwin.nt.gov.au/live/about-darwin.

Deloitte 2014, *2014 Global Survey of R&D Tax Incentives*, Deloitte Touche Tohmatsu Limited, New York, https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Tax/dttl-tax-global-rd-survey-aug-2014.pdf.

Denzin, N 1978, *Sociological Methods*, McGraw-Hill, New York.

Denzin, N 2000, *Handbook of Qualitative Research*, SAGE Publications.

Department of Industry, Tourism and Resources (Industry Policy Division) 2006, *Collaboration and Other Factors Influencing Innovation Novelty in Australian Businesses: An Econometric Analysis*, http://www.industry.gov.au/innovation/reportsandstudies/Documents/CollaborationInnovationNovelty.pdf.

Department of Natural Resources and Mines 2014, *About Coal Seam Gas (CSG) and Liquefied Natural Gas (LNG)*, https://www.dnrm.qld.gov.au/mining/coal-seam-gas/about/overview?SQ_DESIGN_NAME=print-guide.

Dolgui, A & Proth, J-M 2010, *Supply Chain Engineering: Useful Methods and Techniques*, Springer, London.

Economist 2006, *Really Big Oil*, viewed Aug 2014 http://www.economist.com/node/7276986.

Economist 2013, *Supermajordämmerung*,, viewed Aug 2014 http://www.economist.com/news/briefing/21582522-day-huge-integrated-international-oil-company-drawing.

Eurostat 2015, *File: Share of Innovative Enterprises, 2010-12*, viewed January 2014 http://ec.europa.eu/eurostat/statistics-explained/index.php/File:Share_of_innovative_enterprises,_2010%E2%80%9312_(%C2%B9)_(%25_of_all_enterprises)_YB15.png.

Fernand, A & Patrick, C 2001, ‘Technology Transfer Revisited From the Perspective of theKknowledge-Based Economy’, vol. 30, no. 9, pp. 1459-78, http://www.sciencedirect.com/science/article/pii/S0048733301001627.

Fisher, ML 1997, 'What is the Right Supply Chain for Your Product?', *Harvard Business Review*, vol. 75, no. 2, pp. 105-17.

Flick, U 2005, *Design and Process in Qualitative Research*, Sage, London.

Fox, MS, Chionglo, JF & Barbuceanu, M 1993, *The Integrated Supply Chain Management System*, Technical report, Department of Industrial Engineering, University of Toronto, Toronto, Ontario, http://www.eil.utoronto.ca/wp-content/uploads/public/papers/iscm-intro.pdf.

Frankelius, P 2009, 'Questioning Two Myths in Innovation', *Journal of High Technology Management Research*, pp. 40-51, http://www.academia.edu/3667333/Questioning_two_myths_in_innovation_literature.

Fraunhofer Institute for Systems and Innovation Research (ISI), German Institute of Global and Area Studies (GIGA) & Georgia Tech, Program in Science, Technology and Innovation Policy (STIP) 2008 , *New Challenges for Germany in the Innovation Competition, http://www.isi.fraunhofer.de/isi-wAssets/docs/p/de/publikationen/new_challenges_for_germany.pdf*.

Galambos L, Hikino, T & Zamagni, V 2007, 'The Development of All-Around Chemical Enterprises', in *The global Chemical Industry in the Age of the Petrochemical Revolution*, Cambridge University Press, Cambridge, pp. 325-7.

Gardner, DL 2001, 'Logistics in the Supply Chain', *Traffic World*, vol. 265, no. 3, pp. 30-1, http://connection.ebscohost.com/c/articles/8590033/logistics-supply-chain.

Gibson, BJ, Mentzer, JT & Cook, RL 2005, 'Supply Chain Management: the Pursuit of a Consensus Definition', *Journal of Business Logistics*, vol. 26, no. 2, pp. 17-25.

Gillham, B 2000, *The Research Interview*, Continuum Intl Pub Group.

Gray, J 2014, ‘Optimizing the Supply Chain in Unconventional Oil and Gas – Part 2’, *Evolve*, viewed May 2014, http://evolve.cc/optimizing-the-supply-chain-in-unconventional-oil-and-gas-part-2.

Halldórsson, Á & Svanberg, M 2013, ‘Energy Resources: Trajectories for Supply Chain Management’, *Supply Chain Management: An International Journal*, vol. 18, no. 1, pp. 66-73.

Haskel, J & Westlake, S 2014, ‘Look to the Intangibles’, *The Economist*, 20 February 2014.

Hatakenaka, S, Westnes, P, Gjelsvik, M & Lester, R 2011, ‘The Regional Dynamics of Innovation: A Comparative Study of Oil and Gas Industry Development in Stavanger and Aberdeen,’ *International Journal of Innovation and Regional Development*, vol. 3, no. 3/4, p. 305.

Haworth, K 2010, ‘All Pipelines Lead to Gladstone: Queensland’s Burgeoning LNG Industry’, *The Australian Pipeliner*, viewed July 2012.

Hendrickson, L, Balaguer, A, Smith, R, Simpson, J, Wood, E, Drake, P, Alinejad, M, Brusse, S & Ford, A 2014, *Australian Innovation System Report 2014*, http://www.industry.gov.au/Office-of-the-Chief-Economist/Publications/Documents/Australian-Innovation-System/Australian-Innovation-System-Report-2014.pdf.

Inkpen, AC & Moffett, MH 2011, *The Global Oil and Gas Industry: Management, Strategy and Finance*, PennWell Corporation, Tulsa, Oklahoma.

International Energy Agency 2016, *Key World Energy Statistics 2016*, IEA, Paris, https://www.iea.org/publications/freepublications/publication/KeyWorld2016.pdf

Inui, TS & Frankel, RM 1991, *Evaluating the Quality of Qualitative Research*, vol. 6, Springer Nature.

Jain, N & Anand, P 2001, ‘A Generalized Model of Operations Reversal for Fashion Goods’, *Management Science*, vol. 47, no. 4, pp. 595-600, http://pubsonline.informs.org/doi/abs/10.1287/mnsc.47.4.595.9830.

Jacoby, D 2012, *Optimal Supply Chain Management in Oil, Gas, and Power Generation*, PennWell Corp, Tulsa, Oklahoma,

Johnson, C 1982, ‘Miti and the Japanese Miracle’, in *The Growth of Industrial Policy : 1925-1975*, Stanford University Press, Stanford, pp. 91-115.

Kielmann, K, Cataldo, F & Seeley, J 2012, *Introduction to Qualitative Research Methodology: A Training Manual*, 2012 edn, UK.

Kelly, G & La Cava, G 2014, *International Trade Costs, Global Supply Chains and Value-Added Trade in Australia*, Reserve Bank of Australia, https://www.rba.gov.au/publications/rdp/2014/pdf/rdp2014-07.pdf.

Lakshman, M, Sinha, L, Biswas, M, Charles, M & Arora, NK 2000, ‘Quantitative Vs Qualitative Research Methods’, *The Indian Journal of Pediatrics*, vol. 67, no. 5, pp. 369-77.

Lee, HL 2002, ‘Aligning Supply Chain Strategies With Product Uncertainties’, *California Management Review*, vol. 44, no. 3, pp. 105-19, http://cmr.ucpress.edu/content/44/3/15.

Leedy, PD & Ormrod, JE 2005, ‘Practical Research’, *Planning and Design*, vol. 8.

Lehnfeld, M 2013, *Germany is Europe’s Innovation Incubator*, http://www.gtai.de/GTAI/Content/EN/Invest/_SharedDocs/Downloads/GTAI/BLG/blg-germany-innovation-incubator.pdf .

Levi, MA, Economy, E, O’Neil, SK & Segal, A 2010, *Energy Innovation: Driving Technology Competition and Cooperation among the United States, China, India, and Brazil*, Council on Foreign Relations, New York.

Library of Congress 2006, *History of the Oil and Gas Industry*, The Library of Congress, http://www.loc.gov/rr/business/BERA/issue5/history.html.

Lim, S & Strutt, A 1994, ‘Japan’s MITI : A Role Model for Australia and New Zealand?’, pp. 23-6.

Lockamy, A & McCormack, K 2004, ‘The Development of a Supply Chain Management Process Maturity Model Using the Concepts of Business Process Orientation’, *Supply Chain Management: An International Journal*, vol. 9, no. 4, pp. 272-8, http://www.emeraldinsight.com/doi/abs/10.1108/13598540410550019.

Marien, EJ 2000, ‘The Four Supply Chain Enablers’, *Supply Chain Management Review*, vol. 2, no. 3, pp. 60-8, http://www.scribd.com/doc/44639604/The-Four-Supply-Chain-Enablers#scribd.

Mayring, P 2007, ‘On Generalization in Qualitatively Oriented Research’, *Forum: Qualitative Social Research*, vol. 8, no. 3, art. 26, http://www.qualitative-research.net/index.php/fqs/article/view/291/641.

Minister Lee Hsien Loong, *Prime Minister's Office Singapore 2015*, http://www.pmo.gov.sg/mediacentre/statement-prime-minister-lee-hsien-loong.

Ministry of Economy, Trade and Industry *2015, History of METI,* http://www.meti.go.jp/english/aboutmeti/data/ahistory.html.

Michaelides, D 2007, *The Art of Innovation: Integrating Creativity in Organizations*, Performa Productions, Ballaugh.

Michaelides, D 2012, *Innovation For Competitive Advantage*, http://www.innovationexcellence.com/blog/2012/04/22/to-innovate-or-not-to-innovate-that-is-not-the-question/.

Miller, T 2001, *Advanced Manufacturing: Hierarchical Operations and Supply Chain Planning*, Springer-Verlag, London.

Minichiello, V, Aroni, R & Hays, T 2008, *In-Depth Interviewing: Principles, Techniques, Analysis*, Pearson Education Australia.

Numbeo 2015, *Quality of Life Comparison Between Singapore and Darwin*, viewed 06/08/2015, http://www.numbeo.com/quality-of-life/compare_cities.jsp?country1=Singapore&city1=Singapore&country2=Australia&city2=Darwin.

OECD 2013a, *Science, Technology and Industry Scoreboard 2013*, http://www.oecd-ilibrary.org/docserver/download/9213051e.pdf?expires=1435983218&id=id&accname=guest&checksum=DC3CDB4B21B0BF498FADF988B083A035.

OECD 2013b, *Hours Worked*, https://data.oecd.org/emp/hours-worked.htm.

OECD 2013c, *Reviews of Innovation Policy- Innovation in Southeast Asia*, OECD.

OECD 2014, ‘Policy Challenges For the Next 50 years’, *OECD Economic Policy Paper*, no. 9, http://www.oecd-ilibrary.org/economics/policy-challenges-for-the-next-50-years_5jz18gs5fckf-en.

OECD 2015, *What Makes Us the OECD*, viewed 04/02/2015, http://www.oecd.org/careers/whatmakesustheoecd.htm.

OECD Development 2013, *OECD Science, Technology and Industry Scoreboard,* Canongate US, Genev.

Economides, M, Oligney, R, & Izquierdo, A 2000, *The Color of Oil : The History, the Money and the Politics of the World’s Biggest Business*, Round Oak Publishing Company, Texas.

Patrick, JL &. Helms, JL 2006, *The Book of Action*, Dog Ear Publishing, USA

Patton, M 1999, *Enhancing the Quality and Credibility of Qualitative Analysis*, Health Services Research.

Patton, M 2011, *Qualitative Evaluation and Research Methods*, 2nd Edition, Sage Publications, CA.

Perrons, RK 2014, ‘How Innovation and R&D Happen in the Upstream Oil & Gas Industry: Insights From a Global Survey’, *Journal of Petroleum Science and Engineering*, vol. 124, pp. 301-12.

Pitman, MA & Maxwell, JA 1992, ‘Qualitative Approaches to Evaluation: Models and Methods’, *The Handbook of Qualitative Research in Education*, vol. 729, p. 770.

Plunkett Corporation Ltd 2010, ‘Transportation Industry Trends: Introduction to the Transportation and Logistics Industry’, www.plunkettresearch.com/Industries/TransportationSupplyChainLogistics/TransportationTrends/tabid/259/Default.aspx.

Putz-Plecko, B 2008, ‘Cultural Education: The Promotion of Cultural Knowledge, Creativity and Intercultural Understanding Through Education’, http://dieangewandte.at/jart/prj3/angewandte/resources/dbcon_def/uploads/Universitaet/Berichte/EreportBparis0812.pdf.

Polit, DF & Beck, CT 2010, ‘Generalization in Quantitative and Qualitative Research: Myths and Strategies’, *International Journal of Nursing Studies*, vol. 47, no. 11, pp. 1451-8.

Roessner, JD 2000, *Science and Technology Policy in the US, A Time of Change*, Longman, London.

Russell, DW & Miyashita, K 1994, *Keiretsu: Inside the Hidden Japanese Conglomerates*, McGraw-Hill, New York.

Sarva, A 2014, *Why Germans Work Fewer Hours But Produce More: A Study in Culture*, The Huffington Post, viewed 20/01/2015, http://www.huffingtonpost.com/amol-sarva/why-germans-work-fewer-ho_b_6172262.htm.

Smelser, N 1973, *The Methodology of Comparative Analysis*, Prentice-Hall, New Jersey.

SBS 2013, *Factbox: CSG in Australia*, SBS, http://www.sbs.com.au/news/article/2013/03/12/factbox-csg-australia.

Schilling, MA 2013, *Strategic Management of Technological Innovation*, vol. 4, McGraw-Hill Education.

Schwengler, P & Freeth, G 2006, ‘Automated Tie-In Technology for Oil and Gas Pipeline Construction’, in *Proceedings of the 23rd World Gas Conference, June 5-9*, International Gas Union, Amsterdam, pp. 708-27, viewed (May 2014) http://www.apga.net.au/wp-content/uploads/2010/06/Paper-04-Schwengler.pdf.

Sherer, SA 2005, ‘From Supply-Chain Management to Value Network Advocacy: Implications For e-Supply Chains’, *Supply Chain Management: An International Journal*, vol. 10, no. 2, pp. 77-83, http://www.emeraldinsight.com/doi/pdfplus/10.1108/13598540510589151.

Sichel, D 2005, *Measuring Capital in the New Economy. Studies in Income and Wealth*, National Bureau of Economic Research, University of Chicago Press.

Simchi-Levi, E & Kaminsky, D 2007, *Designing and Managing the Supply Chain*, McGraw-Hill Education, New York City.

Singapore Economic Development Board 2015, *Energy: Industry Background*, https://www.edb.gov.sg/content/edb/en/industries/industries/energy.html.

Soames, L, Brunker, D & Talgaswatta, T 2011, *Competition, Innovation and Productivity in Australian Businesses*, Australian Bureau of Statistics, http://www.ausstats.abs.gov.au/Ausstats/subscriber.nsf/0/896C28E59CC4B822CA2579050014C578/$File/1351055035_sep%202011.pdf.

Society of Petroleum Engineers 2015, *Captains of Industry Champion Oil and Gas Upstream Technical Advancements* (news release), http://www.spe.org/events/apogce/2015/documents/15APOG-NewsRelease-5Mar.pdf.

Steckler, A, McLeroy, KR, Goodman, RM, Bird, ST & McCormick, L 1992, *Toward Integrating Qualitative and Quantitative Methods: An Introduction*, vol. 19, SAGE Publications.

Stephens, S 2001, 'Supply Chain Council and Supply Chain Operations Reference (SCOR) Model Overview', *Supply Chain Council, Inc., Pittsburgh, USA*

timeanddate.com 2015, *Distance Calculator*, viewed 06/08/2015, <http://www.timeanddate.com/worldclock/distanceresult.html?p1=236&p2=72>.

Urciuoli, L, Mohanty, S, Hintsa, J & Gerine Boekesteijn, E 2014, 'The Resilience of Energy Supply Chains: A Multiple Case Study Approach on Oil and Gas Supply Chains to Europe', *Supply Chain Management: An International Journal*, vol. 19, no. 1, pp. 46-63.

Von Tunzelmann, N & Acha, V 2006, *Innovation in "Low-Tech" Industries*, Oxford University Press, viewed January 2014, http://dx.doi.org/10.1093/oxfordhb/9780199286805.003.0015.

White House 2011, *A Strategy for American Innovation: Securing Our Economic Growth and Prosperity*, White House, Washington, https://www.whitehouse.gov/sites/default/files/uploads/InnovationStrategy.pdf

Woo, B 2013, *Innovation Distinguishes Between a Leader and a Follower*, Forbes, https://www.forbes.com/sites/bwoo/2013/02/14/innovation-distinguishes-between-a-leader-and-a-follower/#c9f460b28447.

World Bank Group 2014, *World Development Indicators,* World Bank Publications, Washington http://data.worldbank.org/sites/default/files/wdi-2014-book.pdf.

Wolf, R 2013, ‘Management Relations in the Work Culture in Japan as Compared to That of the West’, *Innovative Journal of Business and Management*, pp. 116-22.

XE Currency 2013, *XE Currency Charts: AUD to SGD*, viewed June 2015, <http://www.xe.com/currencycharts/?from=AUD&to=SGD&view=5Y>.

Yi, T 2010, *The Oil and Gas Service Industry in Asia: A Comparison of Business Strategies*, Palgrave Macmillan.

Yin, RK 2011, *Qualitative Research from Start to Finish*, The Guilford Press, New York.

Yin, RK 2013, *Case Study Research: Design and Methods*, SAGE Publications.

Yusuf, YY, Gunasekaran, A, Adeleye, EO & Sivayoganathan, K 2004, ‘Agile Supply Chain Capabilities: Determinants of Competitive Objectives’, *European Journal of Operational Research*, vol. 159, no. 2, pp. 379-92, <http://ac.els-cdn.com/S0377221703005241/1-s2.0-S0377221703005241-main.pdf?_tid=53df25ee-1fa8-11e5-9fa7-00000aab0f02&acdnat=1435724532_23d4690f66440920893264cc722f8da4>.

Bibliography:

'Really Big Oil', 2006, *The Economist*, viewed Aug 2014, <http://www.economist.com/node/7276986>.

'2014 global R&D funding forecast', 2013, *Battelle*, viewed December, <http://www.battelle.org/docs/tpp/2014_global_rd_funding_forecast.pdf>.

2014, created by *Exploiting unconventional oil fields requires overcoming tough logistics challenges*, viewed January 1 <http://www.forbes.com/sites/stevebanker/2014/01/20/exploiting-unconventional-oil-fields-requires-overcoming-tough-logistics-challenges/>.

2014 global survey of R&D tax incentives, 2014, Deloitte, London,<https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Tax/dttl-tax-global-rd-survey-aug-2014.pdf>.

Global survey of R&D tax incentives, 2014, Deloitte Touche Tohmatsu Limited, New York,<https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Tax/dttl-tax-global-rd-survey-aug-2014.pdf>.

Eurostat 2015, Vincent bourgeais
Geneviève Villette

Acha, V 2002, *University of Sussex*, vol. null.

Acha, V & Cusmano, L 2005, 'Governance and co-ordination of distributed innovation processes: patterns of R&D co-operation in the upstream petroleum industry', *Economics of Innovation and New Technology*, vol. 14, no. 1-2, pp. 1-21.

Admiral Gehman H 2003, *Report of Columbia Accident Investigation Board*,

NASA,
NASA,<http://history.nasa.gov/columbia/Troxell/Columbia%20Web%20Site/Documents/Congress/Senate/SEPTEM~1/gehman_statement.html>.

Afuah, A 2012, *Innovation management: Strategies implementation & profits* Oxford University Press, New York.

Allen, MC 2009, 'Germany's national innovation system', in *Encyclopedia of technology and innovation management*, Oxford, Blackwell, ch 375-389.

Amesse, F & De Bresson, A 1991, 'Technology, globalisation and economic performance', *Research Policy*, vol. 20, no. null, p. 363.

Davies D & Hobday M 2005, *The Business of Projects: Managing Innovation in Complex products and systems* Cambridge University Press.

Angeles, R 2005, 'RFID technologies: supply-chain applications and implementation issues', *Information Systems Management*, vol. 22, no. 1, pp. 51-65.

APICS 2011, 'APICS', in *SpringerReference*, Springer Science + Business Media.

Askevold, E, Gjesvik, M & Steineke, J 1999, *Breaking up is hard to do: Organizational learning and outsourcing in the norwegian oil industry*, null.

Austrade 2015, *Oil and gas to Singapore*, <http://www.austrade.gov.au/Export/Export-Markets/Countries/Singapore/Industries/Oil-and-gas#.VYZbDzCqpBc>.

Australian Bureau of Statistics 2014, *Innovation in Australian business 2012-13* ABS, <http://www.abs.gov.au/ausstats/abs@.nsf/mf/8158.0#>.

Bagby, JW 1992, 'Public and industrial policy barriers to independent vertical integration: Reflections of Keiretsu', *Working Paper on the Law of Business Organizations*, p. 7.

Banker, S 2014, 'The upstream shale oil supply chain', *Forbes*, viewed January 2015, <http://www.forbes.com/sites/stevebanker/2014/08/08/the-upstream-unconventional-oil-gas-supply-chain/>.

Bass, C 2012, *The innovation and creativity*, viewed 20/10/2014, <http://www.talkmgt.com/blog/2012/05/24/carl-bass-the-innovation-and-creativity-connection-at-c2-mtl/>.

Bell, J, Frater, B, Butterfield, L, Cunningham, S, Dogson, M, Fox, K, Spurling, T & Webster, E 2014, *The role of science, research and technology in lifting Australian productivity*, http://www.acola.org.au/PDF/SAF04Reports/SAF04%20Role%20of%20SRT%20in%20lifting%20Aus%20Productivity%20FINAL%20REPORT.pdf>.

Benson, SNK 2009, 'A review of “observation techniques: structured to unstructured”', *The Journal of Educational Research*, vol. 103, no. 1, pp. 63-4.

Blaustein, RS 2014, 'Comparative Innovation Strategies and Technology Transfer: U.S. Efforts', *US Department of Energy*, viewed 10 September 2014, <http://csis.org/files/attachments/100914_RBlaustein.pdf>.

Bloomberg 2014, *Most innovative in the world 2014: Countries*, http://images.businessweek.com/bloomberg/pdfs/most_innovative_countries_2014_011714.pdf>.

Bloomberg 2014, created by Bloomberg, viewed January <http://images.businessweek.com/bloomberg/pdfs/most_innovative_countries_2014_011714.pdf>.

Most innovative in the world 2014: countries 2014, created by Bloomberg,

viewed January
<http://images.businessweek.com/bloomberg/pdfs/most_innovative_countries_2014_011714.pdf>.

Bozeman, B 2000, 'Technology transfer and public policy: a review of research and theory', *Technology transfer; Public policy; Research; Theory*, pp. 1-3.

BP Statistical Review 2014, *Bp statistical review of world energy*, BPStats, London,<https://www.bp.com/content/dam/bp/pdf/Energy-economics/statistical-review-2014/BP-statistical-review-of-world-energy-2014-full-report.pdf>.

Breschi, S & Cusmano, L 2004, 'Unveiling the texture of a european research area: Emergence of oligarchic networks under EU framework programmes', *International Journal of Technology Management*, vol. 27, no. 8, pp. 747-72.

British Petroleum 2013, *BP statistical review of world energy*, British Petroleum, London, June 2013,
<http://www.bp.com/content/dam/bp/pdf/statistical-review/statistical_review_of_world_energy_2013.pdf>.

Britto, J 1998, *University of Sussex*, vol. ‘Governance and co-ordination of distributed innovation processes: patterns of R&D co-operation in the upstream petroleum industry’
Volume 14, 2005 - Issue 1-2: Microeconomics and Innovation

Brown, J 2015, 'Fueling the oil and gas supply chain', *Inbound Logistics*, July, (blog), viewed July 2014,
<http://www.inboundlogistics.com/cms/article/fueling-the-oil-and-gas-supply-chain/>.

Brusoni, S & Prencipe, A 2001, 'Unpacking the black box of modularity:

Technologies, products, organisations', *Industrial and corporate change*, vol. 10, no. 1, p. 179.

Brusoni, S & Sadowski, B 2007, *Falmer*, Kluwer Academic Publisher, Moscow.

Brusoni, S, Prencipe, A & Pavitt, K 1990, 'Architectural innovation: The reconfiguration of existing product technologies and the failure of established firms', *Administrative Science Quarterly*, vol. 35, pp. 9-30.

Buckley, JW, M. H. Buckley and H. Chiang 1976, 'Research Methodology & Business Decisions'.

Burt, D, Dobler, D & Starling 2003, 'World class supply management: the key to supply chain management', vol. 7th Edition, no. McGraw-Hill, New York.

Cachon, GP 2004, 'The allocation of inventory risk in a supply chain: Push, pull, and advance-purchase discount contracts', *Management Science*, vol. 50, no. 2, pp. 222-38.

Chima, CM 2007, 'Supply-chain management issues in the oil and gas industry', *Journal of Business & Economics Research*, vol. 5, no. 6, pp. 28-36.

Chopra, S & Meindl, P 2007, *Supply chain management. Strategy, planning & operation*, 5th edn, Pearson Prentice Hall, Upper Saddle River, NJ.

Chu, S 2006, 'Exploring the relationships of trust and commitment in supply chain management', *The journal of American Academy of Business*, vol. 9, no. 3, pp. 224-8.

Churchill, GA 1999, 'Marketing research: Methodological foundations', *Fort Worth, TX*.

Close, D 2006, 'Building the high-performance E&P company', *Journal of Petroleum Technology*.

Commission, P 2014, 'PC productivity update 2014'.

Conway, W 1909, 'Climbing in the "land of fire"', *The Wide World Magazine*, vol. 22, pp. 145-8.

Coombs, R & Metcalfe, JS 2000, *Organising for innovation: coordinating for innovative distributed innovation capabilities*, Oxford University Press, Oxford.

Coombs, R & Metcalfe, JS 2000, *Competence, Governance and Entrepreneurship*, Oxford University Press, Oxford.

Coombs, R, Harvey, M & Tether, B 2004, ' Analysing distributed processes of provision and innovation', *Industrial and Corporate Change*, vol. 12, no. 6, pp. 1125-56.

Cooper, DR, Schindler, Pamela S 1998, 'Business research methods'. 7th edn, vol. 3, McGraw Hill International Edition.

Cornell University, INSEAD & WIPO 2013, *The global innovation index 2013: local dynamics of innovation*, Cornell University, INSEAD, and the World Intellectual Property Organization (WIPO), Geneva, Ithaca, and Fontainebleau,<http://www.wipo.int/edocs/pubdocs/en/economics/gii/gii_2013.pdf>.

Cox, A, Chicksand, L & Ireland, P 2001, 'E-supply applications: the inappropriateness of certain internet solutions for SMEs', in *10th International Annual IPSERA Conference*: *proceedings of the10th International Annual IPSERA Conference* International Purchasing and Supply Education and Research Association (IPSERA), pp. 189-200.

Crump, JG 1997, 'Strategic alliances fit pattern of industry innovation', *Oil and Gas Journal*, vol. 95, no. 13, pp. 59-63.

Cummins, JG 2005, 'A new approach to the valuation of intangible capital', in *Measuring capital in the new economy*, University of Chicago Press, pp. 47-72.

Darwin City Council 2015, *About Darwin*, <http://www.darwin.nt.gov.au/live/about-darwin>.

Davies D & Michael Hobday M 2005, *The Business of Projects: Managing Innovation in Complex products and systems* Cambridge University Press.

Deloitte 2014, '2014 Global survey of R&D tax incentives', *Deloitte*, viewed March, <https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Tax/dttl-tax-global-rd-survey-aug-2014.pdf>.

Denzin N, YSL 2000, *Handbook of qualitative research*, SAGE Publications.

Department of Industry Tourism and Resources 2006, *Collaboration and other factors influencing innovation novelty in australian businesses*, http://www.industry.gov.au/innovation/reportsandstudies/Documents/CollaborationInnovationNovelty.pdf>.

Department of Natural Resources and Mines 2014, *About coal seam gas (CSG) and liquefied natural gas (LNG)*, https://www.dnrm.qld.gov.au/mining/coal-seam-gas/about/overview?SQ_DESIGN_NAME=print-guide>.

Dolgui, A & Proth, J-M 2010, *Supply chain engineering: useful methods and techniques*, Springer, London.

Dolgui, A & Proth, J-M 2013, 'Supply chain engineering: useful methods and techniques', *Production Planning & Control*, vol. 24, no. 6, pp. 546-7.

EBD 2015, *Energy*, Singapore Economic Development Board, <https://www.edb.gov.sg/content/edb/en/industries/industries/energy.html>.

National Oil Companies 2006, created by Economist, T, viewed Aug 10 <http://www.economist.com/node/7276986>.

Supermajordämmerung 2013, created by Economist, viewed 12 Sep 2014, <http://www.economist.com/news/briefing/21582522-day-huge-integrated-international-oil-company-drawing>.

Supermajordämmerung 2013, created by Economist, T, viewed Aug 3 <http://www.economist.com/news/briefing/21582522-day-huge-integrated-international-oil-company-drawing>.

Supermajordämmerung 2013, created by Economist, 'The global oil industry: Supermajordämmerung', *The Economist*, Aug 3.

Eurostat 2015, created by Eurostat, viewed January 20 <http://ec.europa.eu/eurostat/statistics-explained/index.php/File:Share_of_innovative_enterprises,_2010%E2%80%9312_(%C2%B9)_(%25_of_all_enterprises)_YB15.png>.

Fernand, A & Patrick, C 2001, 'Technology transfer revisited from the perspective of the knowledge-based economy', vol. 30, no. 9, pp. 1459-78.

Fisher, ML 1997, 'What is the right supply chain for your product?', *Harvard Business Review*, vol. 75, no. 2, pp. 105-17.

The upstream shale oil supply chain 2014, created by Forbes, viewed Auggues 8 <http://www.forbes.com/sites/stevebanker/2014/08/08/the-upstream-unconventional-oil-gas-supply-chain/>.

Exploiting unconventional oil fields requires overcoming tough logistics challenges 2014, created by Forbes, viewed January 1 <http://www.forbes.com/sites/stevebanker/2014/01/20/exploiting-unconventional-oil-fields-requires-overcoming-tough-logistics-challenges/>.

Fox, MS, Chionglo, JF & Barbuceanu, M 1993, *The integrated supply chain management system*, Technical report, Department of Industrial Engineering, University of Toronto, Toronto, Ontario,<http://www.eil.utoronto.ca/wp-content/uploads/public/papers/iscm-intro.pdf>.

Frankelius, P 2009, 'Questioning two myths in innovation', *Journal of High Technology Management Research*, pp. 40-51.

Galambos L, Takashi Hikino & Zamagni, V 2007, 'The development of all-around chemical enterprises', in *The global chemical industry in the age of the petrochemical revolution*, Cambridge University Press, Cambridge, pp. 325-7.

Gardner, DL 2001, 'Logistics in the supply chain', *Traffic World*, vol. 265, no. 3, pp. 30-1.

Gibson, BJ, Mentzer, JT & Cook, RL 2005, 'Supply chain management: the pursuit of a consensus definition', *Journal of business logistics*, vol. 26, no. 2, pp. 17-25.

Gillham, B 2000, *The research interview*, Continuum Intl Pub Group.

Gillham, B 2000, 'The research interview', no. Continuum Intl Pub Group.

Global Innovation Index 2013, 'The global innovation index 2013', *Global Innovation Index*, <http://www.wipo.int/edocs/pubdocs/en/economics/gii/gii_2013.pdf>.

Global R&D Funding Forecast 2014 2013, 'Global R&D funding forecast

2014', *R&D Magazine*, viewed December 2014, <http://www.battelle.org/docs/tpp/2014_global_rd_funding_forecast.pdf>.

Group, WB 2014, *World development indicators* World Bank Publications, Washington <http://data.worldbank.org/sites/default/files/wdi-2014-book.pdf>.

Gryna, F 2011, 'Supply chain management' in quality planning & analysis', no. The McGraw-Hill Companies, pp. 403-32.

Gulati, R 1999, 'Alliances and networks', *Strategic management journal*, vol. 20, pp. 293-317.

Gulati, R & Gargiulo, M 1999, 'Where do interorganizational networks come from? ', *American Journal of Sociology*, vol. 103, pp. 1439-93.

Gulati, R, Nohria, N & Zaheer, A 2000, 'Strategic networks', *Strategic Management Journal*, vol. 21, no. null, p. 203.

Haskel, J & Westlake, S 2014, 'Look to the intangibles', *The Economist*, Feb 20th 2014, <http://www.economist.com/blogs/freeexchange/2014/02/investment>.

Haworth, K 2010, 'All pipelines lead to Gladstone: Queensland's burgeoning LNG industry', *The Australian Pipeliner*, viewed July 2012, <http://pipeliner.com.au/news/all_pipelines_lead_to_gladstone_queenslands_burgeoning_lng_industry/041805/>.

Henderson, RM & Clark, KB 1990, 'Architectural innovation: The reconfiguration of existing product technologies and the failure of established firms', *Administrative Science Quarterly*, vol. 35, no. null, pp. 9-30.

Hendrickson, L, Balaguer, A, Smith, R, Simpson, J, Wood, E, Drake, P, Alinejad, M, Brusse, S & Ford, A 2014, *Australian innovation system report*

2014, http://www.industry.gov.au/Office-of-the-Chief-Economist/Publications/Documents/Australian-Innovation-System/Australian-Innovation-System-Report-2014.pdf>.

Hines, T 2004, *Supply Chain Strategies: Customer Driven and Customer Focused*, Butterworth-Heinemann.

Hugos, MH 2011, *Essentials of supply chain management*, vol. 62, John Wiley & Sons.

Index, GI 2013, *The global innovation index 2013: The local dynamics of innovation*, World Intellectual Property Organization Geneva,<http://www.wipo.int/edocs/pubdocs/en/economics/gii/gii_2013.pdf>.

Inkpen, AC & Moffett, MH 2011, *The global oil & gas industry: Management, strategy & finance*, PennWell Corporation, Tulsa, Oklahama.

Jaklic, J, Groznik, A & Kovacic, A 2003, 'The role of simulation modeling: simulations in industry', *Informing Science: International Journal of an Emerging Transdiscipline*, vol. 6, pp. 257-62.

Jane Ritchie, Jane Lewis & Elam, G 2003, 'Qualitative research practice: a guide for social science students and researchers', *Choice Reviews Online*, vol. 41, no. 03, pp. 41-1319-41-.

Johnson, C 1982, 'Miti and the Japanese miracle', in *The Growth of Industrial Policy : 1925-1975*, Standford University Press, Standford, pp. 91-115.

Johnson, C & Smith, RW 2008, 'Technology transfer: Moving knowledge from research into industry standards', in *2008 7th International Pipeline Conference, Volume 4*: *proceedings of the 2008 7th International Pipeline Conference, Volume 4* ASME International.

Kariyawasam, S & Huang, T 2014, 'How safe failure pressure ratios are related to %smys', in *Volume 2: Pipeline Integrity Management*: *proceedings of the Volume 2: Pipeline Integrity Management* ASME International.

Kelly, G & La Cava, G *International trade costs, global supply chains and value-added trade in Australia*, Reserve Bank of Australia, http://www-dr.rba.gov.au/publications/rdp/2014/pdf/rdp2014-07.pdf>.

Kogut, B, Shan, W & Walker, G 1992, *Networks and organizations: Structure, form and actions*, vol. null.

Kuglin, FA 1998, *Customer-centered supply chain management: a link-by-link guide*, Amacom New York, NY.

Lambert, DM & Cooper, MC 2000, 'Issues in supply chain management', *Industrial Marketing Management*, vol. 29, no. 1, pp. 65-83.

Langlois, RN 2002, 'Modularity in technology and organization', *Journal of economic behavior and organization*, vol. 49, no. null, pp. 19-37.

Lee, HL 2002, 'Aligning supply chain strategies with product uncertainties', *California Management Review*, vol. 44, no. 3, pp. 105-19.

Leedy, PD & Ormrod, JE 2005, 'Practical research', *Planning and design*, vol. 8.

Lehnfeld, M 2013, *Germany is europe's innovation incubator*, http://www.gtai.de/GTAI/Content/EN/Invest/_SharedDocs/Downloads/GTAI/BLG/blg-germany-innovation-incubator.pdf>.

Lehnfeld M 2013, *New challenges for germany in the innovation competition*.

Levi, MA, Economy, E, Shannon Kathleen, ON & Segal, A 2010, *Energy innovation: Driving technology competition and cooperation among the* *united states, china, india, and brazil*, Council on Foreign Relations, New York.

Lim, S & Strutt, A 1994, 'Japan's MITI : a role model for Australia and New Zealand?', pp. 23-6.

Limited, IU 1994, *Analyzing qualitative data*, http://id.crossref.org/isbn/978-0-203-31651-1, <http://dx.doi.org/10.4324/9780203413081>.

Lockamy, A & McCormack, K 2004, 'The development of a supply chain management process maturity model using the concepts of business process orientation', *Supply chain management: An international journal*, vol. 9, no. 4, pp. 272-8.

Marien, EJ 2000, 'The four supply chain enablers', *Supply Chain Management Review*, vol. 2, no. 3, pp. 60-8.

Martínez Sánchez, A & Pérez Pérez, M 2005, 'Supply chain flexibility and firm performance', *International Journal of Operations & Production Management*, vol. 25, no. 7, pp. 681-700.

Merriam, SB 1998, *Qualitative research and case study applications in education*, ERIC.

History of METI 2015, created by METI, http://www.meti.go.jp/english/aboutmeti/data/ahistory.html>.

Michaelides, D 2007, *The art of innovation: Integrating creativity in organizations*, Performa Productions, Ballaugh.

Miller, T 2001, *Advanced manufacturing: hierarchical operations and supply chain planning*, Springer-Verlag, London.

Minichiello, V, Aroni, R & Hays, T 2008, *In-depth interviewing: Principles,* *techniques, analysis*, Pearson Education Australia.

Ministry of economy trade and industry of Japan 2015, *History of METI*, <http://www.meti.go.jp/english/aboutmeti/data/ahistory.html>.

Nikhil, J & Anand, P 2001, 'A generalized model of operations reversal for fashion goods', *Management Science*, vol. 47, no. 4, pp. 595-600.

Nohria, N & Eccles, RG 1992, *Networks and organizations: Structure, form and actions*, Harvard Business School Press, Boston.

Numbeo 2015, *Quality of Life Comparison Between Singapore and Darwin*, viewed 06/08/2015, <http://www.numbeo.com/quality-of-life/compare_cities.jsp?country1=Singapore&city1=Singapore&country2=Australia&city2=Darwin>.

OECD 2011, 'Skills for innovation and research'.

OECD 2013, *Hours worked* OECD, https://data.oecd.org/emp/hours-worked.htm>.

OECD 2013, *Reviews of innovation policy innovation in Southeast Asia*, OECD.

OECD 2013, *Science, technology and industry scoreboard 2013*, OECD, <http://www.oecd-ilibrary.org/docserver/download/9213051e.pdf?expires=1435983218&id=id&accname=guest&checksum=DC3CDB4B21B0BF498FADF988B083A035>.

OECD 2013, *Hours Worked,* https://data.oecd.org/emp/hours-worked.htm>.

Hours worked 2013, created by OECD, https://data.oecd.org/emp/hours-worked.htm>.

OECD 2014, 'Policy challenges for the next 50 years', *OECD Economic Policy Paper*, no. 9.

OECD 2015, *What makes us the OECD*, viewed 04/02/2015, <http://www.oecd.org/careers/whatmakesustheoecd.htm>.

OECD Development 2013, *OECD science, technology and industry scoreboard* Canongate US, Genev.

Orlikowski, WJ & Gash, DC 1994, 'Technological frames: making sense of information technology in organizations', *ACM Transactions on Information Systems*, vol. 2, no. 2, p. 174.

Orsenigo, L, Pammolli, F, Riccaboni, M, Bonaccorsi, A & Turchetti, G 1998, ' The dynamics of knowledge and of the evolution of network structure', *Journal of Management and Governance*, vol. 1, no. 2, p. 147.

Pavitt, K 1998, 'Technologies, products and organization in the innovating firm: what Adam Smith tells us and Joseph Schumpeter doesn't', *Industrial and Corporate Change*, vol. 7, no. 3, pp. 433-52.

Pavitt, K 1999, *Technology, management and system of innovation*, Edward Elgar Publishing, London.

Pitman, MA & Maxwell, JA 1992, 'Qualitative approaches to evaluation: Models and methods', *The handbook of qualitative research in education*, vol. 729, p. 770.

Plunkett Corporation Ltd 2010, 'Transportation industry trends: introduction to the transportation & logistics industry'.

Powell, WW, Koput, KW & Smith-Doerr, L 1996, 'Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology', *Administrative Science Quarterly*, vol. 41, no. null, pp. 116-

45.

Power, DJ, Sohal, AS & Rahman, SU 2001, 'Critical success factors in agile supply chain management - An empirical study', *International Journal of Physical Distribution & Logistics Management*, vol. 31, no. 4, pp. 247-65.

Putz-Plecko, B 2008, 'Cultural education: The promotion of cultural knowledge, creativity and intercultural understanding through education'.

Quintas, P 2003, *Networks, alliances and partnerships in the innovation process*, vol. null.

Rafhati R, R 2011, 'Supply Chain Management Practices in Malaysia Oil and Gas Industry: A Case Study of Murphy Sarawak Oil Company Ltd', Universiti Utara Malaysia.

Rodrigue, J-P, Comtois, C & Slack, B 2013, *The geography of transport systems*, 2 edn, Routledge.

Roessner, JD 2000, *Science and technology policy in the us, a time of change*, Longman, London.

Ronald Oligney, Armando Izquierdo & Economides, M 2000, *The color of oil : The history, the money and the politics of the world's biggest business*, Round Oak Publishing Company, Texas.

Russell, KMaDW 1994, *Keiretsu: Inside the hidden Japanese conglomerates*, Mcgraw-Hill, New York.

Saad, S, Udin, ZM & Hasnan, N 2013, 'Dynamic supply chain management in oil and gas industry', in *3rd Asia-Pacific Business Research Conference*: *proceedings of the3rd Asia-Pacific Business Research Conference*.

Sahwney, M & Prandelli, E 2000, 'Communities of creation: Managing distributed innovation in turbulent markets', *California Management Review*, vol. 42, no. 4, p. 24.

Samaranayake, P 2005, 'A conceptual framework for supply chain management: a structural integration', *Supply Chain Management: An International Journal*, vol. 10, no. 1, pp. 47-59.

Sarva, A 2014, *Why germans work fewer hours but produce more: A study in culture*, The Huffington Post, viewed 20/01/2015, <http://www.huffingtonpost.com/amol-sarva/why-germans-work-fewer-ho_b_6172262.html>.

Schilling, MA 2013, *Strategic management of technological innovation*, vol. 4th.

Schilling, MA & Steensma, HK 2001, 'Strategic management of technological innovation', *Academy of Management Journal*, vol. 44, no. 6, p. 1149.

Schmitz, J & Platts, KW 2004, 'Supplier logistics performance measurement: Indications from a study in the automotive industry', *International Journal of Production Economics*, vol. 89, no. 2, pp. 231-43.

Schwengler, P & Freeth , G 2006, 'Automated tie-in technology for oil and gas pipeline construction', in *23rd World Gas Conference, June 5-9*: *proceedings of the23rd World Gas Conference, June 5-9* International Gas Union, Amsterdam, pp. 708-27, viewed <http://www.apia.net.au/wp-content/uploads/2010/06/Paper-04-Schwengler.pdf>.

Sherer, SA 2005, 'From supply-chain management to value network advocacy: implications for e-supply chains', *Supply Chain Management: An International Journal*, vol. 10, no. 2, pp. 77-83.

Sichel, D 2005, *Measuring capital in the new economy. Studies in income and wealth*, National Bureau of Economic Research, University of Chicago

Press.

Simchi-Levi, E & Kaminsky, D 2007, *Designing and managing the supply chain*. McGraw-Hill Education, New York City.

David Simchi-Levi D, Kaminsky, P & Simchi-Levi., E 2000, *Designing and managing the supply chain* vol. 17, Emerald, Irwin/McGraw-Hill.

Simon, H A 1996, *The sciences of artificial*, vol. MIT Press, London

Soames, L, Brunker, D & Talgaswatta, T 2011, *Competition, innovation and productivity in Australian businesses*, Australian Bureau of Statistics, http://www.ausstats.abs.gov.au/Ausstats/subscriber.nsf/0/896C28E59CC4B822CA2579050014C578/$File/1351055035_sep%202011.pdf>.

Statistics, Australian Bureau of Statistics, *Innovation in Australian business 2012-13 2013*, <http://www.abs.gov.au/ausstats/abs@.nsf/mf/8158.0>.

Statistics, Australian BureauBeauro of Statistics 2014, *Innovation in australian business*, Australian Bureau of Statistics, Canbera, 21 Jan 2015, <http://www.abs.gov.au/ausstats/abs@.nsf/mf/8158.0>.

Statistics, ABo 2014 *Innovation in Australian Business*, http://www.abs.gov.au/ausstats/abs@.nsf/mf/8158.0>.

Stephens, S 2001, 'Supply chain operations reference model version 5.0: A new tool to improve supply chain efficiency and achieve best practice', *Information Systems Frontiers*, vol. 3, no. 4, pp. 471-6.

Stewart, G 1997, 'Supply-chain operations reference model (SCOR): the first cross-industry framework for integrated supply-chain management', *Logistics information management*, vol. 10, no. 2, pp. 62-7.

Tatikonda, MV & Stock, GN 2003, 'Product technology transfer in the upstream supply chain', *Journal of Product Innovation Management*, vol. 20, no. 6, pp. 444-67.

Taylor, DH 1997, *Global cases in logistics and supply chain management*, Cengage Learning EMEA.

Teubal, M, Yinnon, T & Zuscovitch, E 1991, 'Systems of innovation: Technologies, institutions and organizations', *Research Policy*, vol. 20, no. null, p. 381.

Time and date 2015, *Distance calculator*, viewed 06/08/2015, <http://www.timeanddate.com/worldclock/distanceresult.html?p1=236&p2=72>.

Tomlinson, S, Zorlu, P & Langley, C 2008, 'Innovation and technology transfer'.

Trace, C 2001, 'Applying content analysis to case study data: A preliminary report'.

Tversky, A & Kahneman, D 1981, 'The framing of decisions and the psychology of choice', *Science*, vol. 211, no. null, p. 453.

Veal, AJ 2005, *Business research methods: A managerial approach*, Pearson Education Australia/Addison Wesley.

von Tunzelmann, N & Acha, V 2006, *Innovation in "low-tech" industries*, Oxford University Press 2006/01/19, <http://dx.doi.org/10.1093/oxfordhb/9780199286805.003.0015>.

WACC 2066, 'What is technology transfer?', *The World Association for Christian Communication 2006*.

Wang, F-Y, Zeng, D & Yang, L 2006, 'Smart cars on smart roads: an IEEE intelligent transportation systems society update', *IEEE Pervasive Computing*, no. 4, pp. 68-9.

Wasserman, S & Faust, K 1994, *Social network analysis: Methods and applications*.

Weick, KE 2000, *Making sense of the organization*.

White House 2011, *A strategy for american innovation: Securing our economic growth and prosperity*, 1234058901, White House, Washington,<https://www.whitehouse.gov/sites/default/files/uploads/InnovationStrategy.pdf>.

Wolf, R 2013, 'Management relations in the work culture in japan as compared to that of the west', *Innovative Journal of Business and Management*, pp. 116-22.

XE Currency 2013, *Xe currency charts (AUD/SGD)*, viewed 21 06 2015, <http://www.xe.com/currencycharts/?from=AUD&to=SGD&view=5Y>.

Yi, T 2010, *The oil and gas service industry in Asia: a comparison of business strategies*, Palgrave Macmillan.

Yin, RK 2013, *Case study research: Design and methods*, Sage publications.

Yusuf, YY, Gunasekaran, A, Adeleye, EO & Sivayoganathan, K 2004, 'Agile supply chain capabilities: Determinants of competitive objectives', *European Journal of Operational Research*, vol. 159, no. 2, pp. 379-92.

Appendices:

Appendix 1 (2014 Global R&D Funding Forecast)

FORECAST GROSS EXPENDITURES ON R&D

		2012			2013			2014		
		GDP PPP Bil, US$	R&D as % GDP	GERD* PPP Bil, US$	GDP PPP Bil, US$	R&D as % GDP	GERD PPP Bil, US$	GDP PPP Bil, US$	R&D as % GDP	GERD PPP Bil, US$
1	United States	15,940	2.8%	447	16,195	2.8%	450	16,616	2.8%	465
2	China	12,610	1.8%	232	13,568	1.9%	258	14,559	2.0%	284
3	Japan	4,704	3.4%	160	4,798	3.4%	163	4,856	3.4%	165
4	Germany	3,250	2.8%	92	3,266	2.8%	92	3,312	2.9%	92
5	South Korea	1,640	3.6%	59	1,686	3.6%	61	1,748	3.6%	63
6	France	2,291	2.3%	52	2,296	2.3%	52	2,319	2.3%	52
7	United Kingdom	2,375	1.8%	43	2,408	1.8%	44	2,454	1.8%	44
8	India	4,761	0.9%	40	4,942	0,85%	42	5,194	0.9%	44
9	Russia	2,555	1.5%	38	2,593	1.5%	38	2,671	1.5%	40
10	Brazil	2,394	1.3%	30	2,454	1.3%	31	2,515	1.3%	33
11	Canada	1,513	1.9%	29	1,537	1.9%	29	1,571	1.9%	30
12	Australia	987	2.3%	22	1,012	2.3%	23	1,040	2.3%	23
13	Taiwan	918	2.3%	21	938	2.3%	22	974	2.4%	23
14	Italy	1,863	1.3%	23	1,829	1.2%	22	1,842	1.2%	22
15	Spain	1,434	1.3%	19	1,415	1.3%	18	1,418	1.3%	18
16	Netherlands	719	2.0%	15	710	2.1%	15	712	2.1%	15
17	Sweden	399	3.4%	14	403	3.4%	14	412	3.4%	14
18	Israel	253	4.3%	11	263	4.2%	11	271	4.2%	11
19	Switzerland	369	2.9%	11	375	2.9%	11	382	2.9%	11
20	Turkey	1,142	0.9%	10	1,185	0.9%	10	1,227	0.9%	11
21	Austria	365	2.8%	10	366	2.8%	10	372	2.8%	10
22	Singapore	332	2.6%	9	344	2.6%	9	355	2.7%	9
23	Belgium	427	2.0%	9	427	2.0%	9	432	2.0%	9
24	Iran	1,016	0.8%	8	1,001	0.8%	8	1,014	0.8%	9
25	Mexico	1,788	0.5%	8	1,809	0.5%	8	1,864	0.5%	8
26	Finland	201	3.8%	8	200	3.6%	7	202	3.5%	7
27	Poland	814	0.8%	6	825	0.8%	6	844	0.8%	7
28	Denmark	214	3.1%	7	214	3.0%	6	217	2.9%	6
29	South Africa	592	1.0%	6	604	1.0%	6	621	1.0%	6
30	Qatar	191	2.8%	5	201	2.8%	6	211	2.7%	6
31	Czech Republic	292	1.8%	5	291	1.8%	5	295	1.8%	5
32	Argentina	755	0.6%	5	781	0.6%	5	803	0.6%	5
33	Norway	282	1.7%	5	287	1.7%	5	293	1.7%	5
34	Malaysia	507	0.8%	4	531	0.8%	4	557	0.8%	5
35	Pakistan	524	0.7%	4	543	0.7%	4	556	0.7%	4
36	Portugal	251	1.5%	4	246	1.5%	4	248	1.4%	4
37	Ireland	195	1.8%	3	196	1.7%	3	200	1.7%	3
38	Saudi Arabia	922	0.3%	2	955	0.3%	3	997	0.3%	3
39	Ukraine	341	0.9%	3	341	0.9%	3	348	0.9%	3
40	Indonesia	1,237	0.1%	2	1,303	0.2%	2	1,374	0.2%	3
	Subtotal (Top 40)	**73,362**	**2.0%**	**1,478**	**75,338**	**2.0%**	**1,518**	**77,896**	**2.0%**	**1,576**
	Rest of World	**10,071**	**0.4%**	**39**	**10,413**	**0.4%**	**40**	**10,837**	**0.4%**	**42**
	Global Spending	**83,434**	**1.8%**	**1,517**	**85,751**	**1.8%**	**1,558**	**88,733**	**1.8%**	**1,618**

*** GERD = Gross Expenditures on Research and Development**
PPP= Purchasing Power Parity (used to normalize)

Source: Battelle, *R&D Magazine*, International Monetary Fund, World Bank, CIA Fact Book

Appendix 2: Ethics Approval Letter

OFFICE OF RESEARCH
Human Research Ethics Committee
PHONE +61 7 4631 2690| FAX +61 7 4631 5555
EMAIL ethics@usq.edu.au

UNIVERSITY OF SOUTHERN QUEENSLAND AUSTRALIA

17 July 2015

Mr Mahmood Davoodian

Dear Daniel

The USQ Human Research Ethics Committee has recently reviewed your responses to the conditions placed upon the ethical approval for the project outlined below. Your proposal is now deemed to meet the requirements of the *National Statement on Ethical Conduct in Human Research (2007)* and full ethical approval has been granted.

Approval No.	**H14REA162**
Project Title	The Roles of Advanced Engineering Technologies in Upstream Supply Chain Portal: a Case Study in the perceived barriers to innovation and technology transfer within the Queensland upstreams's supply chain network
Approval date	17 July 2015
Expiry date	17 July 2018
HREC Decision	**Approved**

The standard conditions of this approval are:

(a) conduct the project strictly in accordance with the proposal submitted and granted ethics approval, including any amendments made to the proposal required by the HREC
(b) advise (email: ethics@usq.edu.au) immediately of any complaints or other issues in relation to the project which may warrant review of the ethical approval of the project
(c) make submission for approval of amendments to the approved project before implementing such changes
(d) provide a 'progress report' for every year of approval
(e) provide a 'final report' when the project is complete
(f) advise in writing if the project has been discontinued.

For (c) to (e) forms are available on the USQ ethics website:
http://www.usq.edu.au/research/ethicsbio/human

Please note that failure to comply with the conditions of approval and the *National Statement (2007)* may result in withdrawal of approval for the project.

You may now commence your project. I wish you all the best for the conduct of the project.

Annmaree Jackson
Ethics Coordinator

Copies to: davoodian.d@gmail.com, David Thorpe, Stephen Goh

Appendix 3: Survey Questionnaire

UNIVERSITY OF SOUTHERN QUEENSLAND AUSTRALIA

The Perceived Barriers of Innovation and Tech-transfer in Australian On-shore Drilling Industry

Welcome to My Survey

* **Your participation will involve the completion of a questionnaire that will take approximately 5-10 minutes of your time for 20 questions.**

Please note that in case you find any question or answer unclear, or you wish to suggest any changes, you can take note during the survey and leave me feedback on the last page.

Project Details

Title of Project: A Case Study in identifying the perceived barriers to innovation and technology transfer within the Australian drilling's supply chain network

Human Research Ethics Approval Number: H14REA162

Research Team Contact Details:

Principal Investigator Details
Mr Daniel Davoodian
Email: davoodian.d@gmail.com
Mobile: 0422 606 389

Supervisor Details:
Dr Steven Goh
Email: Steven.Goh@usq.edu.au
Mobile: 0412 628 798

Statement of Consent

By clicking "Yes" below, you are indicating that you:

- Have read and understood the information document regarding this project.

- Have had any questions answered to your satisfaction.
- Understand that if you have any additional questions you can contact the research team.
- Understand that you are free to withdraw at any time, without comment or penalty.
- Understand that you can contact the University of Southern Queensland Ethics Coordinator on (07) 4631 2690 or email ethics@usq.edu.au if you do have any concern or complaint about the ethical conduct of this project.
- Are over 18 years of age.
- Agree to participate in the project.

Have you read and understood the information document regarding this project and agree to participate in the project ?

◯ Yes

◯ No

UNIVERSITY OF SOUTHERN QUEENSLAND
AUSTRALIA

The Perceived Barriers of Innovation and Tech-transfer in Australian On-shore Drilling Industry

Survey Questions

To what extent does the Australian on-shore drilling industry utilise the latest technological innovation?

Rank your answers on a scale of 1 to 5, with 1 being the lowest ranking and 5 being the highest ranking.

- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5

UNIVERSITY OF SOUTHERN QUEENSLAND
AUSTRALIA

The Perceived Barriers of Innovation and Tech-transfer in Australian On-shore Drilling Industry

Survey Questions

To what extent does other industry's lack of innovation and tech-transfer affect the drilling industry ?

Rank your answers on a scale of 1 to 5, with 1 being the lowest ranking and 5 being the highest ranking.

- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5

UNIVERSITY OF SOUTHERN QUEENSLAND
AUSTRALIA

The Perceived Barriers of Innovation and Tech-transfer in Australian On-shore Drilling Industry

Survey Questions

What are the key influencing factors for innovation and technology transfer within the Australian on-shore drilling industry in terms of supply chain and its operating environment ?

- [ ] Poor networking and collaboration
- [ ] Poor levels of capital investment in innovation R&D
- [ ] Obstructive government policies and poor government procurement of innovation
- [ ] Geographical isolation
- [ ] Domination of local businesses which are seeking local competitive advantage rather than pushing the innovation frontiers
- [ ] Poor innovation culture
- [ ] Lack of skilled people
- [ ] Lack of educated local people
- [ ] Lack of necessary high level technologies
- [ ] Other (please specify)

To what extent do the mentioned key influencing factors create and promote barriers to the innovation and technology transfer?

Rank your answers on a scale of 1 to 5, with 1 being the lowest ranking and 5 being the highest ranking.
You can also add other influencing factors or any opinion in the comment section, if necessary.

	1	2	3	4	5	N/A
Poor networking and collaboration	○	○	○	○	○	○
Poor levels of capital investment in innovation R&D	○	○	○	○	○	○
Obstructive government policies and poor government procurement of innovation	○	○	○	○	○	○
A geographical isolation	○	○	○	○	○	○
Domination of local businesses which are seeking local competitive advantage rather than pushing the innovation frontiers	○	○	○	○	○	○
Poor innovation culture	○	○	○	○	○	○
Lack of skilled people	○	○	○	○	○	○
Lack of educated local people	○	○	○	○	○	○
Lack of necessary high level technologies	○	○	○	○	○	○

Other influencing factors or notes:

UNIVERSITY OF SOUTHERN QUEENSLAND
AUSTRALIA

The Perceived Barriers of Innovation and Tech-transfer in Australian On-shore Drilling Industry

Survey Questions

Does your company collaborate and share ideas with any other company overseas?

- ◯ Yes
- ◯ No

UNIVERSITY OF SOUTHERN QUEENSLAND
AUSTRALIA

The Perceived Barriers of Innovation and Tech-transfer in Australian On-shore Drilling Industry

Survey Questions

If yes, to what extent do they share ideas ?

Rank your answers on a scale of 1 to 5, with 1 being the lowest ranking and 5 being the highest ranking.

- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5

UNIVERSITY OF SOUTHERN QUEENSLAND
AUSTRALIA

The Perceived Barriers of Innovation and Tech-transfer in Australian On-shore Drilling Industry

Survey Questions

Does your company collaborate and share ideas with any other company locally?

- ◯ Yes
- ◯ No

UNIVERSITY OF SOUTHERN QUEENSLAND
AUSTRALIA

The Perceived Barriers of Innovation and Tech-transfer in Australian On-shore Drilling Industry

Survey Questions

If yes, to what extent do they share ideas ?

Rank your answers on a scale of 1 to 5, with 1 being the lowest ranking and 5 being the highest ranking.

- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5

UNIVERSITY OF SOUTHERN QUEENSLAND
AUSTRALIA

The Perceived Barriers of Innovation and Tech-transfer in Australian On-shore Drilling Industry

Survey Questions

Does government directly and indirectly support innovation in your company?

- ◯ Yes
- ◯ No

UNIVERSITY OF SOUTHERN QUEENSLAND
AUSTRALIA

The Perceived Barriers of Innovation and Tech-transfer in Australian On-shore Drilling Industry

Survey Questions

Do you have any officer/department responsible for innovation?

- ◯ Yes
- ◯ No

UNIVERSITY OF SOUTHERN QUEENSLAND
AUSTRALIA

The Perceived Barriers of Innovation and Tech-transfer in Australian On-shore Drilling Industry

Survey Questions

If yes, how effective you think these supports are?

Rank your answers on a scale of 1 to 5, with 1 being the lowest ranking and 5 being the highest ranking.

- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5

UNIVERSITY OF SOUTHERN QUEENSLAND
AUSTRALIA

The Perceived Barriers of Innovation and Tech-transfer in Australian On-shore Drilling Industry

Survey Questions

If yes, how effective is it ?

Rank your answers on a scale of 1 to 5, with 1 being the lowest ranking and 5 being the highest ranking.

- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5

UNIVERSITY OF SOUTHERN QUEENSLAND
AUSTRALIA

The Perceived Barriers of Innovation and Tech-transfer in Australian On-shore Drilling Industry

Survey Questions

If there is no one specific, do you think it is effective to have someone in charge?

Rank your answers on a scale of 1 to 5, with 1 being the lowest ranking and 5 being the highest ranking.

- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5

UNIVERSITY OF SOUTHERN QUEENSLAND
AUSTRALIA

The Perceived Barriers of Innovation and Tech-transfer in Australian On-shore Drilling Industry

Survey Questions

Is the concept of innovation clearly covered by your company policies?

- ◯ Yes
- ◯ No

UNIVERSITY OF SOUTHERN QUEENSLAND
AUSTRALIA

The Perceived Barriers of Innovation and Tech-transfer in Australian On-shore Drilling Industry

Survey Questions

How much does your company/department spend on innovation and innovation related activities per year?

- $1000-$50,000
- $50,000-$100,000
- $100,000-$500,000
- $500,000-$1,000,000
- More than $1,000,000
- No idea

UNIVERSITY OF SOUTHERN QUEENSLAND
AUSTRALIA

The Perceived Barriers of Innovation and Tech-transfer in Australian On-shore Drilling Industry

Survey Questions

Does the company's management system, reward employees and departments regarding innovation ideas?

- ◯ Yes
- ◯ No

UNIVERSITY OF SOUTHERN QUEENSLAND AUSTRALIA

The Perceived Barriers of Innovation and Tech-transfer in Australian On-shore Drilling Industry

Survey Questions

How do you source, support and manage ideas within your team/department to support innovation opportunities?

- [ ] Workshops
- [ ] Regular gatherings
- [ ] Problem solving gatherings
- [ ] Rewarding system
- [ ] Other (please specify)

UNIVERSITY OF SOUTHERN QUEENSLAND AUSTRALIA

The Perceived Barriers of Innovation and Tech-transfer in Australian On-shore Drilling Industry

Survey Questions

Do you have a method of measuring the result of innovation plans such as effects, outcomes and motives at all stages of the process?

- ○ Yes
- ○ No

UNIVERSITY OF SOUTHERN QUEENSLAND
AUSTRALIA

The Perceived Barriers of Innovation and Tech-transfer in Australian On-shore Drilling Industry

Survey Questions

How many of below mentioned innovation ideas have been suggested or even implemented in the last year in below areas?

Process:	
Procedure innovation:	
Policy:	
Goods related innovations:	
Others (Please specify) :	

UNIVERSITY OF SOUTHERN QUEENSLAND AUSTRALIA

The Perceived Barriers of Innovation and Tech-transfer in Australian On-shore Drilling Industry

Survey Questions

Thank you for your participation. If there are any suggestions, please do not hesitate to leave feedback.

Enjoy the rest of your day.

Appendix 4: Interview Questions

UNIVERSITY OF SOUTHERN QUEENSLAND AUSTRALIA

The Perceived Barriers of Innovation and Tech-transfer in Australian On-shore Drilling Industry

Interview Questions

The Government report shows that there is poor collaboration record between Australian industry sectors – including the drilling sector- what do you think the reason is?

Why do these barriers exist?

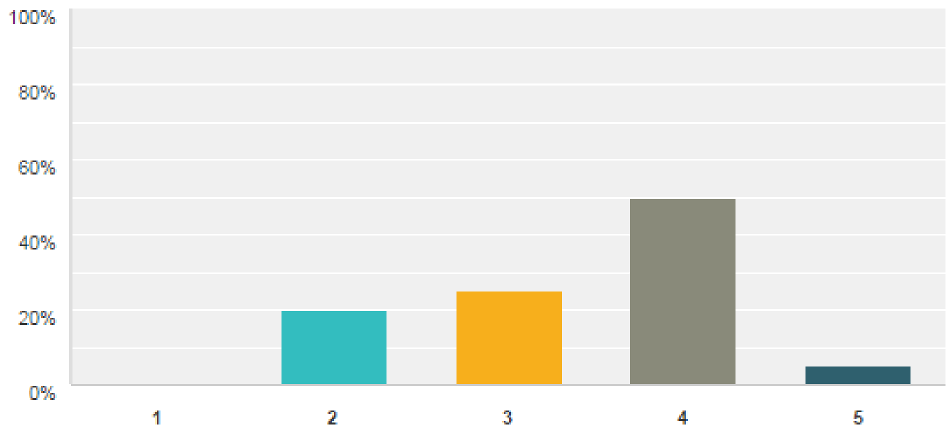
What kind of innovation do you wish you could have done?

What are the reasons you could not achieve them?

Appendix 5: Survey Answers

To what extent does the Australian on-shore drilling industry utilise the latest technological innovation? Rank your answers on a scale of 1 to 5, with 1 being the lowest ranking and 5 being the highest ranking.

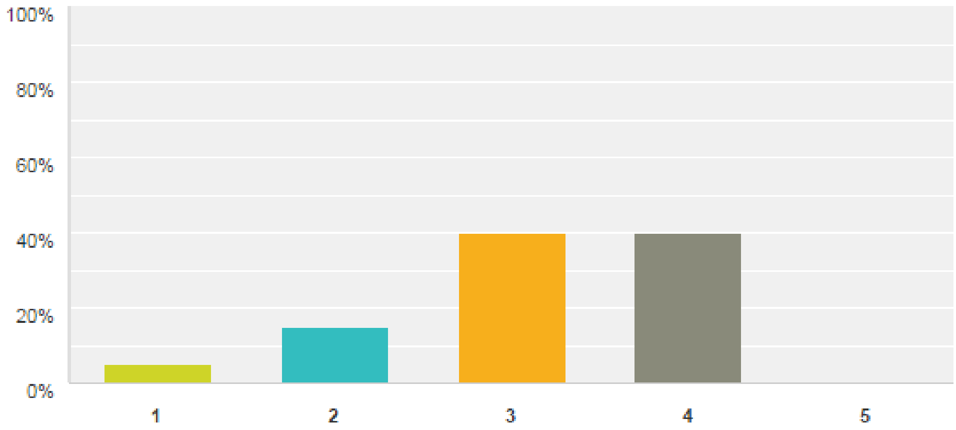
Answered: 20 Skipped: 0



Answer Choices	Responses	
1	0%	0
2	20%	4
3	25%	5
4	50%	10
5	5%	1
Total		20

To what extent does other industry's lack of innovation and tech-transfer affect the drilling industry ? Rank your answers on a scale of 1 to 5, with 1 being the lowest ranking and 5 being the highest ranking.

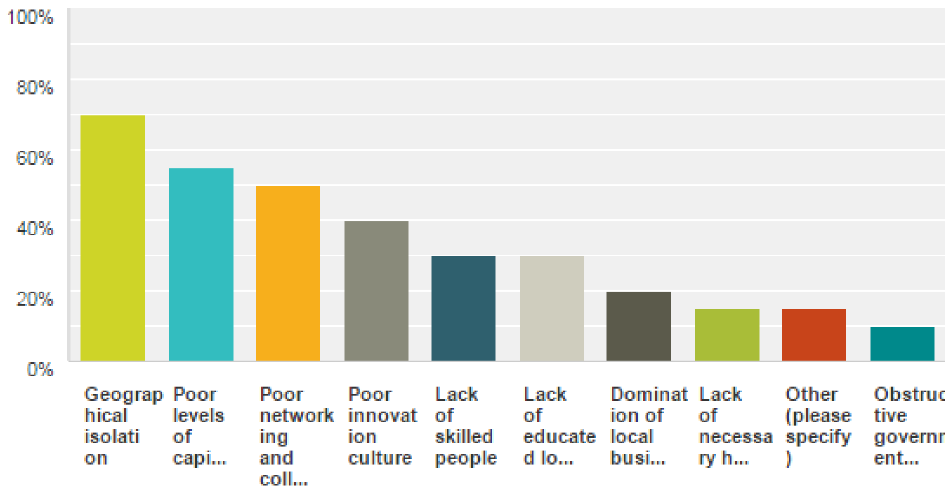
Answered: 20 Skipped: 0



Answer Choices	Responses	
1	5%	1
2	15%	3
3	40%	8
4	40%	8
5	0%	0
Total		20

What are the key influencing factors for innovation and technology transfer within the Australian on-shore drilling industry in terms of supply chain and its operating environment ?

Answered: 20 Skipped: 0



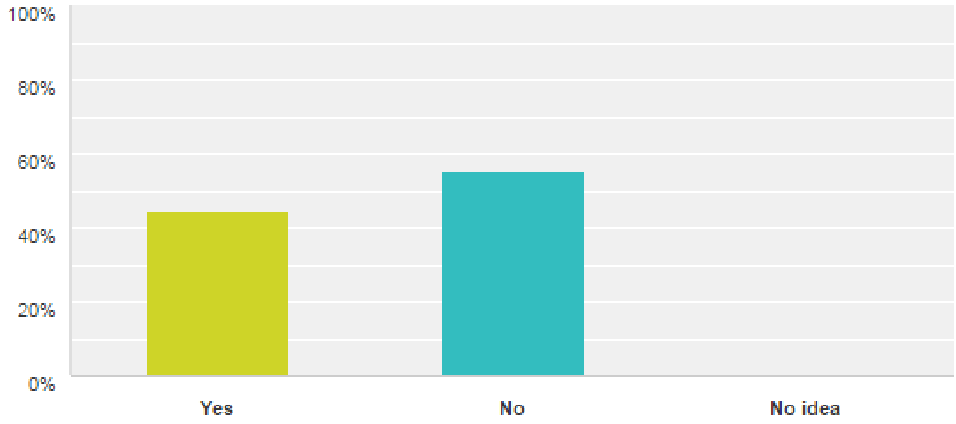
Answer Choices	Responses	
Geographical isolation	70%	14
Poor levels of capital investment in innovation R&D	55%	11
Poor networking and collaboration	50%	10
Poor innovation culture	40%	8
Lack of skilled people	30%	6
Lack of educated local people	30%	6
Domination of local businesses which are seeking local competitive advantage rather than pushing the innovation frontiers	20%	4
Lack of necessary high level technologies	15%	3
Other (please specify) Responses	15%	3
Obstructive government policies and poor government procurement of innovation	10%	2
Total Respondents: 20		

	1	2	3	4	5	N/A	Total	Weighted Average
Poor networking and collaboration	0% 0	6% 1	18% 3	53% 9	24% 4	0% 0	17	1.00
Poor levels of capital investment in innovation R&D	17% 3	6% 1	17% 3	22% 4	33% 6	6% 1	18	1.00
Obstructive government policies and poor government procurement of innovation	31% 5	25% 4	13% 2	25% 4	0% 0	6% 1	16	1.00
A geographical isolation	6% 1	6% 1	11% 2	56% 10	22% 4	0% 0	18	1.00
Domination of local businesses which are seeking local competitive advantage rather than pushing the innovation frontiers	17% 3	17% 3	50% 9	11% 2	0% 0	6% 1	18	1.00
Poor innovation culture	11% 2	17% 3	28% 5	17% 3	28% 5	0% 0	18	1.00
Lack of skilled people	0% 0	18% 3	41% 7	24% 4	12% 2	6% 1	17	1.00
Lack of educated local people	17% 3	17% 3	33% 6	22% 4	6% 1	6% 1	18	1.00
Lack of necessary high level technologies	12% 2	0% 0	59% 10	24% 4	0% 0	6% 1	17	1.00

Comments (1)

Does your company collaborate and share ideas with any other company overseas?

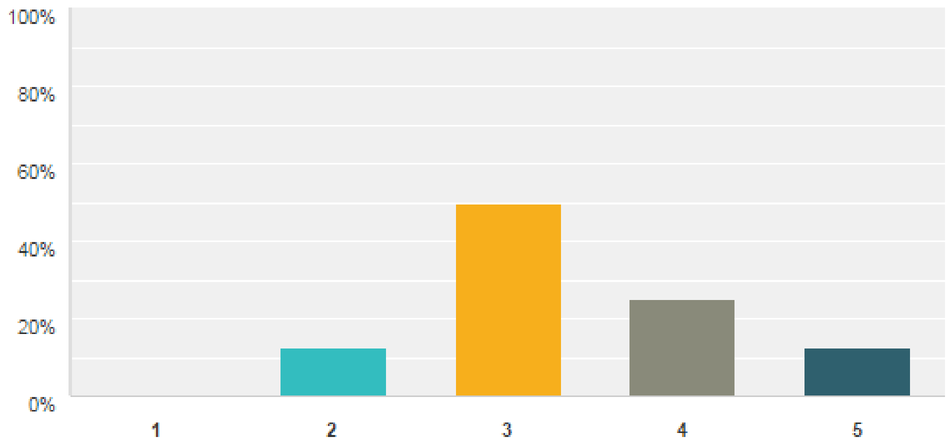
Answered: 18   Skipped: 2



Answer Choices	Responses	
Yes	44%	8
No	56%	10
No idea	0%	0
Total		18

If yes, to what extent do they share ideas ? Rank your answers on a scale of 1 to 5, with 1 being the lowest ranking and 5 being the highest ranking.

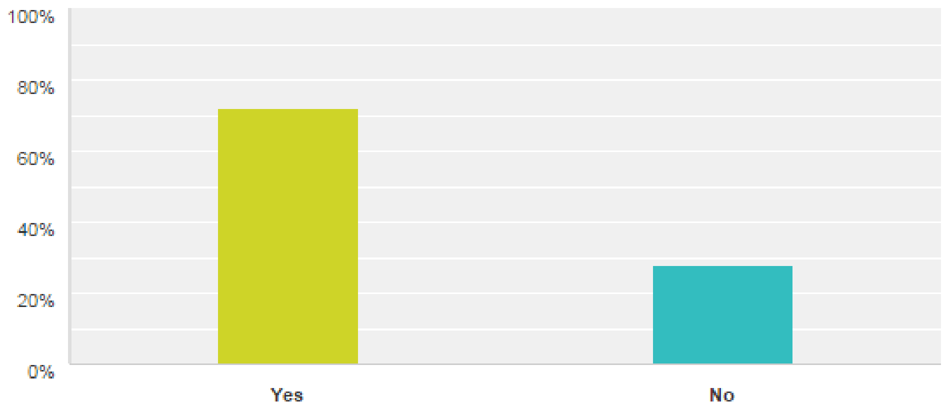
Answered: 8 Skipped: 12



Answer Choices	Responses	
1	0%	0
2	13%	1
3	50%	4
4	25%	2
5	13%	1
Total		8

Does your company collaborate and share ideas with any other company locally?

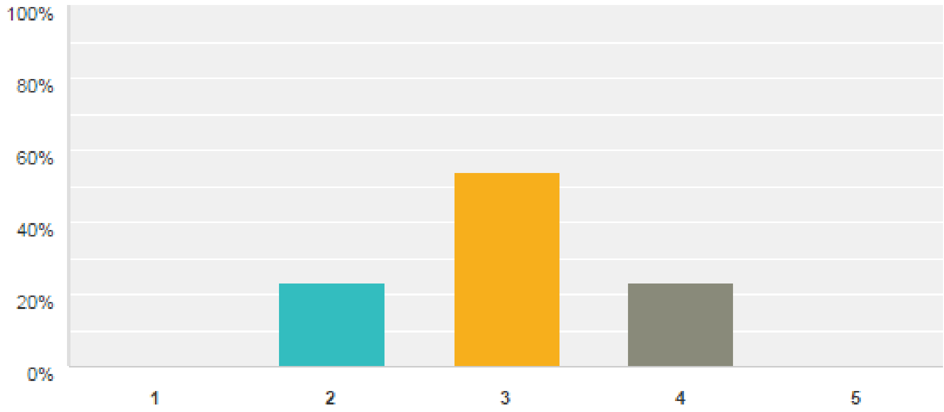
Answered: 18 Skipped: 2



Answer Choices	Responses	
Yes	72%	13
No	28%	5
Total		18

If yes, to what extent do they share ideas ? Rank your answers on a scale of 1 to 5, with 1 being the lowest ranking and 5 being the highest ranking.

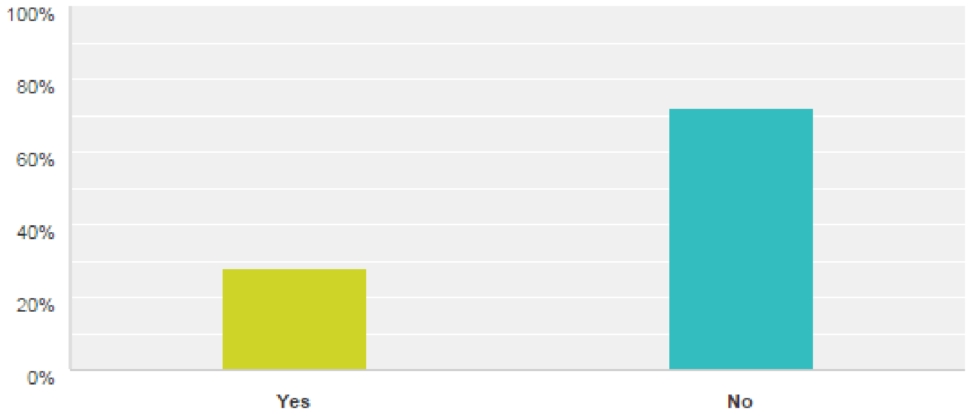
Answered: 13   Skipped: 7



Answer Choices	Responses	
1	0%	0
2	23%	3
3	54%	7
4	23%	3
5	0%	0
Total		13

Does government directly and indirectly support innovation in your company?

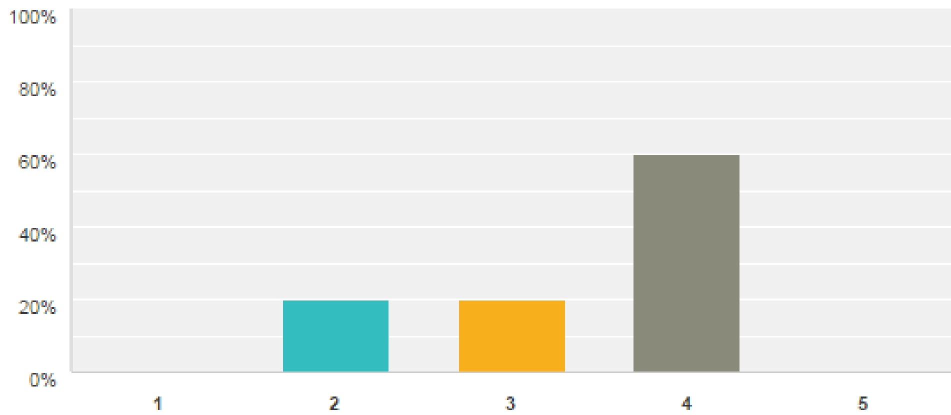
Answered: 18   Skipped: 2



Answer Choices	Responses	
Yes	**28%**	5
No	**72%**	13
Total		18

If yes, how effective you think these supports are? Rank your answers on a scale of 1 to 5, with 1 being the lowest ranking and 5 being the highest ranking.

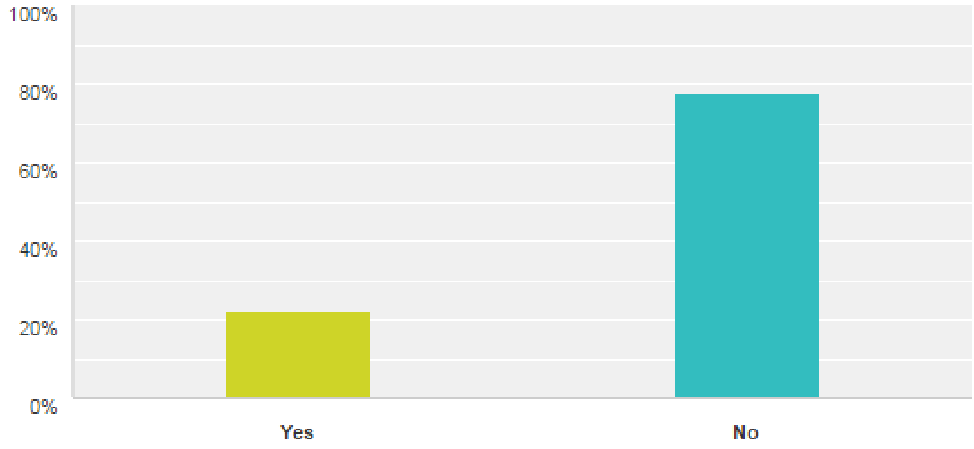
Answered: 5 Skipped: 15



Answer Choices	Responses	
1	0%	0
2	20%	1
3	20%	1
4	60%	3
5	0%	0
Total		5

Do you have any officer/department responsible for innovation?

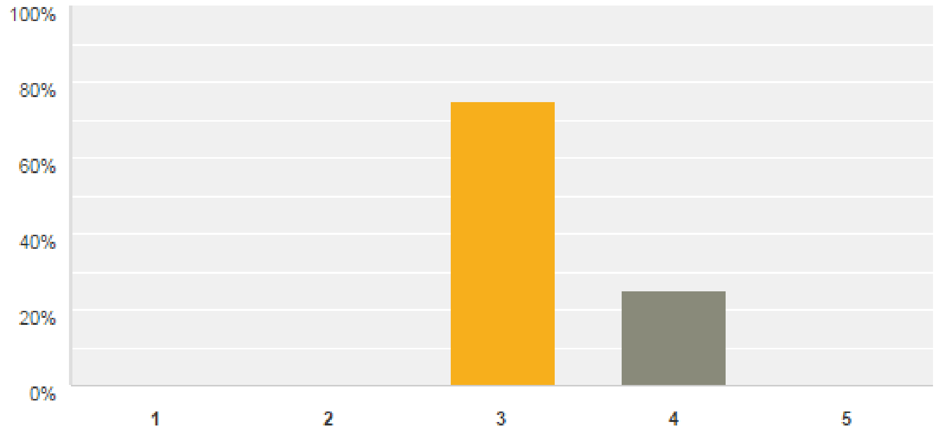
Answered: 18   Skipped: 2



Answer Choices	Responses	
Yes	22%	4
No	78%	14
Total		18

If yes, how effective is it ? Rank your answers on a scale of 1 to 5, with 1 being the lowest ranking and 5 being the highest ranking.

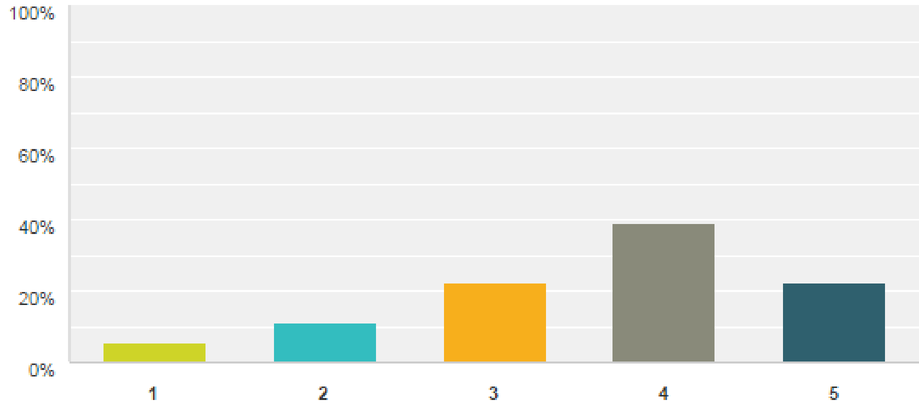
Answered: 4 Skipped: 16



Answer Choices	Responses	
1	0%	0
2	0%	0
3	75%	3
4	25%	1
5	0%	0
Total		4

If there is no one specific, do you think it is effective to have someone in charge? Rank your answers on a scale of 1 to 5, with 1 being the lowest ranking and 5 being the highest ranking.

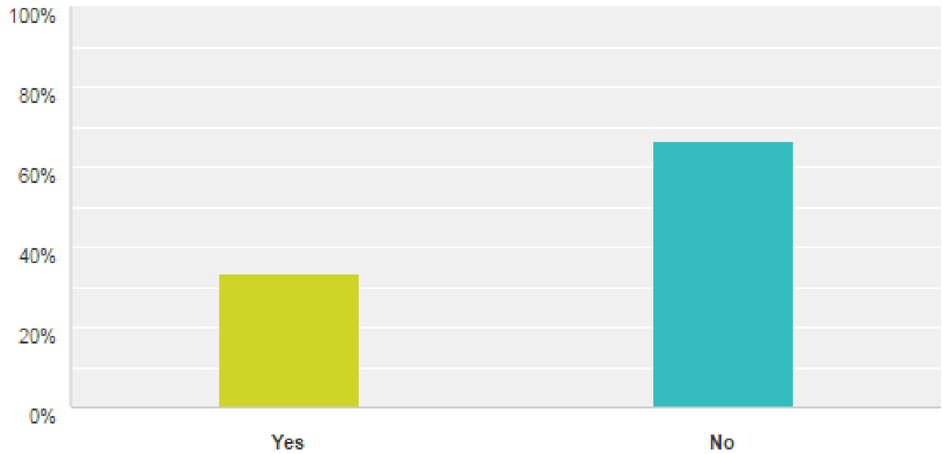
Answered: 18 Skipped: 2



Answer Choices	Responses	
1	6%	1
2	11%	2
3	22%	4
4	39%	7
5	22%	4
Total		18

Is the concept of innovation clearly covered by your company policies?

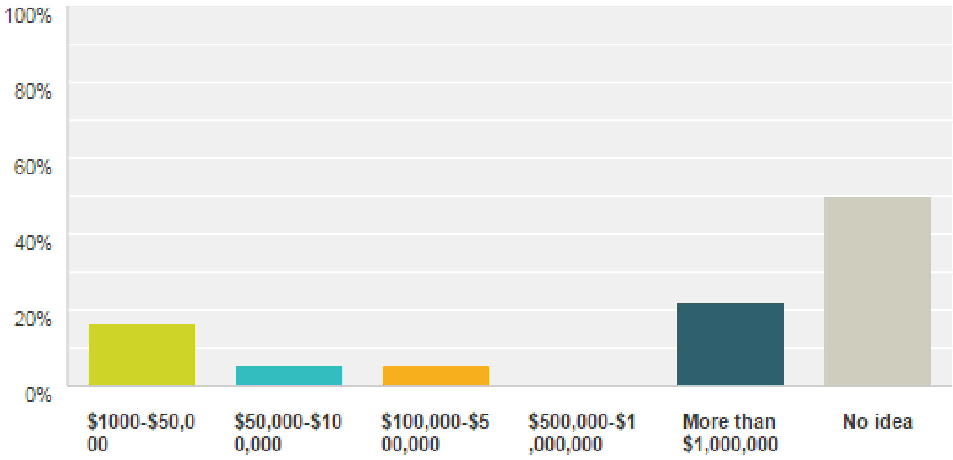
Answered: 18 Skipped: 2



Answer Choices	Responses	
Yes	33%	6
No	67%	12
Total		18

How much does your company/department spend on innovation and innovation related activities per year?

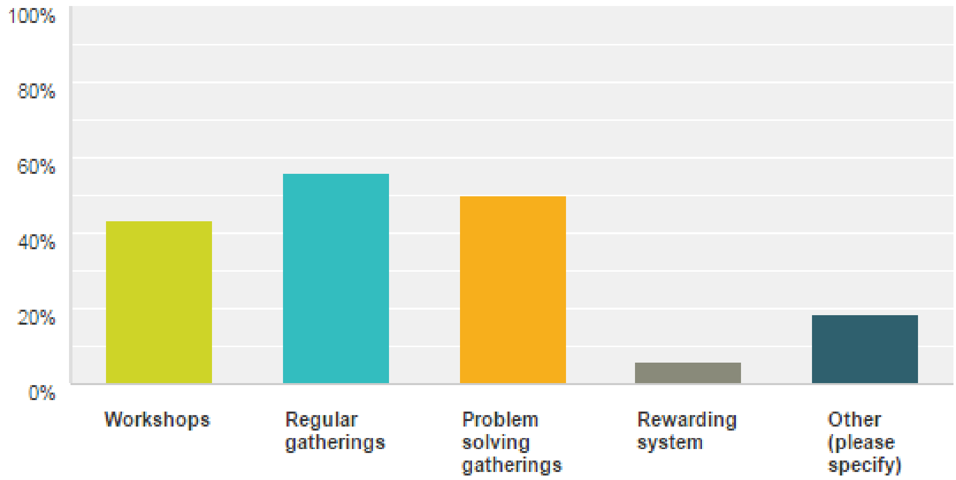
Answered: 18 Skipped: 2



Answer Choices	Responses	
$1000-$50,000	17%	3
$50,000-$100,000	6%	1
$100,000-$500,000	6%	1
$500,000-$1,000,000	0%	0
More than $1,000,000	22%	4
No idea	50%	9
Total		18

How do you source, support and manage ideas within your team/department to support innovation opportunities?

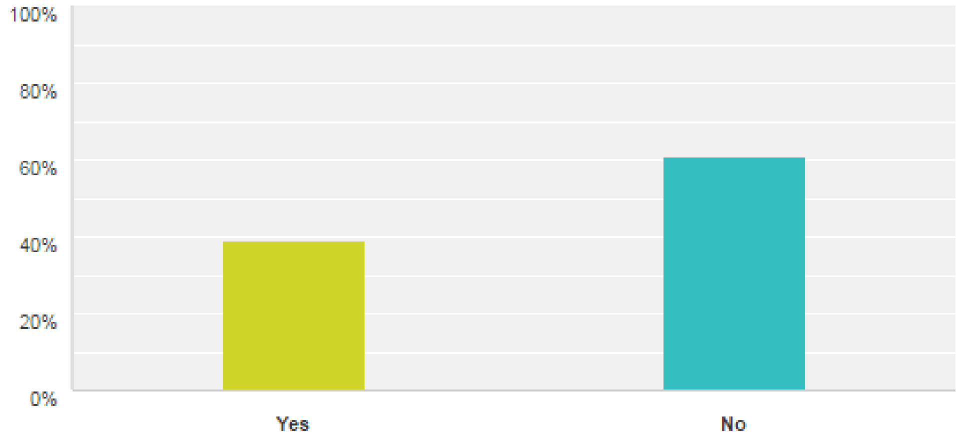
Answered: 16 Skipped: 4



Answer Choices		Responses	
Workshops		44%	7
Regular gatherings		56%	9
Problem solving gatherings		50%	8
Rewarding system		6%	1
Other (please specify)	Responses	19%	3
Total Respondents: 16			

Do you have a method of measuring the result of innovation plans such as effects, outcomes and motives at all stages of the process?

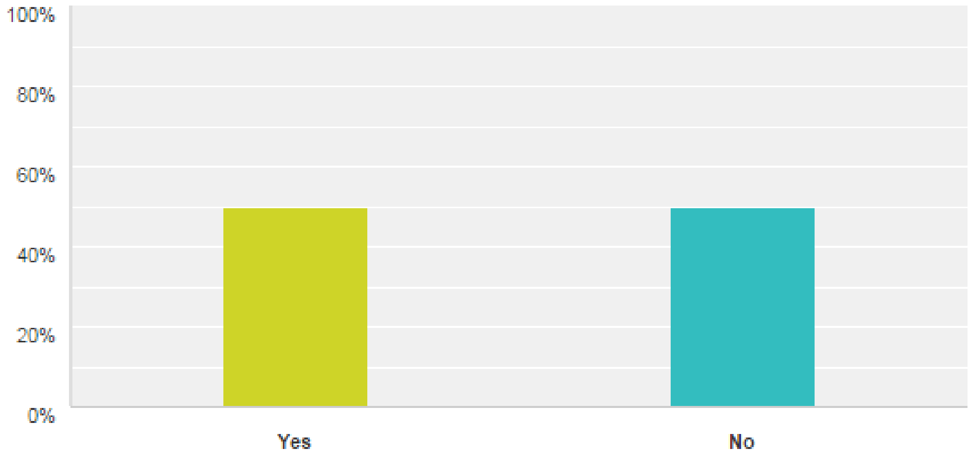
Answered: 18   Skipped: 2



Answer Choices	Responses	
Yes	39%	7
No	61%	11
Total		18

Does the company's management system, reward employees and departments regarding innovation ideas?

Answered: 18 Skipped: 2



Answer Choices	Responses	
Yes	50%	9
No	50%	9
Total		18

How many of below mentioned innovation ideas have been suggested or even implemented in the last year in below areas?

Answered: 12 Skipped: 8

Answer Choices		Responses	
Process:	Responses	100%	12
Procedure innovation:	Responses	83%	10
Policy:	Responses	92%	11
Goods related innovations:	Responses	58%	7
Others (Please specify) :	Responses	25%	3

Thank you for your participation. If there are any suggestions, please do not hesitate to leave feed back.Enjoy the rest of your day.

Answered: 2 Skipped: 18

Responses (2) | Text Analysis | My Categories (0)

Categorize as... | Filter by Category | Search responses

Showing **2** responses

- Some responses need to allow comments as the response options will not capture the intent of the response.
  8/6/2015 11:52 AM View respondent's answers Categorize as...

- There are less barriers than ever before in regards to tech transfer and innovative safety and efficiency ideas. Inter and intra company collaboration has never been more present in the onshore Australian drilling industry. Initiatives such as Safer Together are continuing to put the right companies and decision makers in the same room.
  7/24/2015 4:10 PM View respondent's answers Categorize as...

Appendix 6: Asia Pacific Oil & Gas Conference and Exhibition Information

APOGCE

Asia Pacific Oil & Gas Conference and Exhibition

Co-Organisers: Society of Petroleum Engineers · IATMI | Official Sponsor: PERTAMINA | Official Supporter: skkmigas

20-22 October 2015 | Bali Nusa Dua Convention Center, Bali, Indonesia

Sustain and Gain: Bending the Curve

Panel & Technical Sessions

Panel 1: Sustaining Asset Integrity in Asia Pacific – Is There Advantage in a Global Outlook?

Mohamad Othman
General Manager – Subsurface
Asset Management
PETRONAS

Kevin Lay
Technical Director
NauticAWT Energy Solutions

Grant Andrew Lintern
Independent Consultant

Panel 2: LNG / FLNG Opportunities and Challenges

Datuk Abdullah Karim
Vice President & Venture Director
LNG Projects - Domestic
Global LNG, Upstream
PETRONAS

Steve Kauffman
Front End Development
Manager - LNG
Shell

Hideki Kurimura
Senior Manager for Full Field
Development
INPEX

Prasanth Kakaraparthi
Senior Analyst
Wood MacKenzie

Panel 3: Managing Mature Fields – The Opportunities and Challenges

Wang Demin
Academician of the Academy of
Engineering of China
PetroChina Daqing Oilfield

Bambang Sunarko
General Manager of SLO
Asset Development
Chevron Indonesia

Martin Cyrot
Deputy Vice President –
Geosciences and Reservoir
Total E&P Indonesia

Farooq Qureshi
Senior Vice President &
Head of Malaysia
Schlumberger Business Consulting, Asia

Panel 4: Overcoming the Barriers to Development

Daniel Wieczynski
Senior Vice President &
General Manager
ExxonMobil Oil Indonesia

Juan Carlos Coral
Vice President of Development
Eni Indonesia

Glyn Jones
Country General Manager
Petrofac Malaysia

David Cavanagh
Managing Director
Integrated Energy Pty. Ltd.

Panel 5: Progress towards the Future in Asia Pacific Unconventional Gas

Jim Stannard
Country Chairman
PETRONAS Australia

Chandra D. Tiranda
President and General Manager
Bukit Energy Indonesia

Arnold Volkenborn
Director and Senior Vice President
Schlumberger Business Consulting, Asia

Technical Sessions

- Case Study I: IOR/EOR/EGR
- Case Study II: Completion and Production
- Case Study III: Production and Drilling
- Case Study IV: Surface and Subsurface Integration and Optimisation
- Cementing Solutions
- Challenge Environment: Deep Water/HPHT
- Deepwater and Subsea Facility
- Deepwater Subsurface/Formation Evaluation
- Drilling Performance
- Drilling Technology
- Environment
- EOR and Beyond
- EOR from Inside Out
- Flow Assurance
- Fracturing Technology
- Gas Supply/Technology
- Health and Safety
- Integrity Management
- Knowledge Management
- Operation Management
- Production Optimisation and Novel Completion
- Regional Focus
- Reservoir Characterisation I
- Reservoir Characterisation II
- Simulation, Artificial Intelligence and Modelling I
- Simulation, Artificial Intelligence and Modelling II
- Strategising in a Volatile Environment
- Surface and Subsurface Integration
- Unconventional Resources I: Completion
- Unconventional Resources II
- Well Integrity

For more information,
contact us at +603 2182 3000,
email spekl@spe.org or visit
www.spe.org/events/apogce/2015

Appendix 7: OMICS International Conference Paper

Certificate of Recognition

OMICS International
conferenceseries.com

OMICS International

2360 Corporate Circle., Suite 400 Henderson, NV 89074-7722, USA
Phone: +1-888-843-8169, Fax: +1-650-618-1417, Toll free: +1-800-216-6499

OMICS International and the Editors of Journal of Petroleum & Environmental Engineering, Journal of Chemical Engineering & Process Technology and Journal of Remote Sensing & GIS wish to thank

Prof/Dr. Daniel Davoodian

Univeristy of Southern Queensland, Australia

for his phenomenal and worthy oral presentation at the "International Conference and Expo on Oil and Gas" held on November 16-18, 2015 in Dubai, UAE

Gedela S Babu
OMICS International, USA

Oil Gas Expo 2015 Organizing Committee Members

Katarzyna Jarmolowicz-Szulc	Robert Enick	Ehssan Nassef
National Research Institute	University of Pittsburgh	Pharos University
Poland	USA	Egypt

Title: Technology Transfer and innovation in Oil and Gas Supply Chain

First Author	Mr Daniel Davoodian
University	University of Southern Queensland
Faculty or Centre	Health, Engineering and Sciences
Campus	TOOWOOMBA
Email	Davoodian.d@gmail.com
Mobile	+61 422 606 389

Second Author	Dr Steven Goh
University	University of Southern Queensland
Faculty or Centre	Health, Engineering and Sciences
Campus	TOOWOOMBA
Email	Steven.goh@usq.edu.au
Phone	+61 746 311 446

Abstract:

Studying and analysing the oil and gas industry's supply chain can be complex and sometimes unclear. A supply chain strategy and policy for this industry, comprises the improvement of boundaries and parameters that controls the interactions between different sectors. However, regardless of how good the current supply chain of the oil and gas is, and how well the policies, strategies and technologies are placed, it still can be improved. On the other hand, improvement requires innovation especially in the operational environment. Operational innovation can simply be a different procedure in dealing with old problems. Over years, oil and gas companies including the drilling sector, develop through merger, acquisition and business divergence. Whereas, growth, development and financial improvement can be achieved through innovation in the operation sector as well. However, the researcher's approach is to review the impact of the value, and effect of the technology transfer on organisational policies, operational policies, knowledge based economy and innovation management of the value chain. In this regard the objective of this paper is to study the extensive technology transfer management issues from the point of knowledge-based economy. The main hypothesis suggests the transformation of the traditional model of the technology transfer to a modern approach. The necessity to improve, grow and expand the knowledge-based economy towards a more efficient system, the lack of transparency amongst operation and knowledge transfer, and lack of focus on vertical and horizontal organizational knowledge transfer, are profound invitations for the remodelling and reinterpretation of the basics of the technology transfer

Introduction:

The researcher’s approach in this paper is to review the impact of the value, and effect of the technology transfer on organisational policies, operational policies, knowledge based economy and innovation management of the value chain; with emphasis on addressing the barriers.

In this regard the objective of this paper is to study the extensive technology transfer management issues from the point of knowledge-based economy. The paper touches the basics of innovation and technology transfer as well the relationship between technology owners and client companies to dig into further elements of oil and gas supply chain.

At the end the paper suggests a different style of approach on the perceived barriers of technology transfer and innovation management, specifically recognition and examination of the different transfer contexts.

The Global Oil & Gas Industry’s Strategy: the relationship between the technology owners and project owners

In order to explain the relationships and the culture of oil and gas drilling, as well as illustrating the importance of innovation and technology transfer, the paper covers some basic concepts. It also covers the general approaches of oil and gas sectors and relationships, in order to create the right mindset for the readers.

Generally, discovery and producing crude oil and natural gas are known as the fundamental activities in the upstream value chain. Access, leasing, and exploration activities are the preliminary point in the value chain as, if an oil and gas company does not obtain a new reserve, there will be no new production opportunities.

Finding new reserves is not only about the technology and cost of seismic analysis and drilling, it is about the laws, regulations, leases, auctions and permits, as well. It is about establishing and managing partnerships, developing innovative new technologies to explore reservoir and negotiating convoluted geopolitics.(Inkpen & Moffett 2011)

However, the technology owners and the projects owners in the highly complicated and dynamic oil and gas industry, have always coexisted. National Oil Companies-as the project owners- manage and control 90% of the global reserves (Economist 2006). Generally NOCs can be divided into 3 groups. National Oil Companies that have limited skills in exploration, development and production, which normally rely on tax collection and royalty fees, such as Brunei National Petroleum Company. NOCs that conduct the upstream activities within their boarder such as QatarGas. And the NOCs that take their skills outside their geographical home boarder like what Petrobras (Brazil) or Petronas (Malaysia) do in the global oil and gas industry. (Inkpen & Moffett 2011)consequently, the conceptual structure of the project owner's approach, dictates the relationship and the flow of technology and innovation policies.

On the other hand International Oil Companies are the technology owners. While NOC's are determined to gain more experience and know-how, IOCs are being asked the unpleasant question of, if the technical knowledge can be purchased or be rented. This means that in case the technology owner company, just sell or let the knowledge to the NOC, the firm will turn into a service contractor similar to many others in the industry and loses it's competitive advantages. (Inkpen & Moffett 2011)

Historically, in 1970, international oil companies - BP, Esso, Gulf Oil, Mobil, Royal Dutch Shell, SoCal and Texaco- owned 85% of the reserves. This number today is less than 10%(Economist 2013). Consequently, IOCs offer a wide range of expertise in order to guarantee their involvement in major developments.

Subsequently, NOCs need of technology and expertise is the condition of life for IOCs and the relationship between the technology owners and the project owner is dictated under the fiscal regimes. This means that the oil and gas companies hold the management and technological knowledge necessary for the evolution, but they simply will not allow the transfer of the knowledge. (Inkpen & Moffett 2011)Discussing this matter further, is way beyond boundaries of this paper.

Nonetheless, back to the concept of technology transfer and innovation, most global models or the relevant academic assessments regarding innovation and technology transfer is about creating or increasing efficiencies in the current system. Also, another purpose is to inject technologies and apply innovations into the industries effectively and efficiently. This is not solitary about how to use technology in a technical way, but it is as well very much related to IOC's and country's internal policies and external political relationships.

However, studying innovation and technology transfer of leading countries, shows that the focus is not merely about being the champion of the technology competition, but it is rather about being the deployer, manufacturer and exporter of the next big innovation in technical and non-technical ways. The Organisation for Economic Co-operation and Development (OECD) strongly claims that in the period to 2060, knowledge based capital and innovation will be the way to overcome the threat of new era, such as the slowdown in economy growth, aging population, etc (OECD 2014).

As Mr Obama -the president of the most innovative country(Global Innovation Index 2013)-also addressed ""*None of us can predict with certainty what the next big industry will be or where the new jobs will come from. Thirty years ago, we couldn't know that something called the Internet would lead to an economic revolution. What we can do -- what America does better than anyone else -- is spark the creativity and imagination of our people* " (White House 2011).

Again, narrowing down the topic of the technology transfer and innovation in the drilling's supply chain, in order to identify the perceived barriers, this section has been divided into 3 categories; government level including the global competitiveness, industry level including the drilling sector and the company level.

Needless to mention that qualitative and quantitative method of data collection has been used to examine the relationship within the company departments and between firms, industry, government and the research centres as well. In addition, international indices have been utilised to translate current innovation situation, technology export and innovation culture with top leading countries.

In this section of the paper, the OECD facts and figures has been utilised and referenced for most empirical evidences as well as other well recognised sources. “the OECD is a unique international organisation which sets the standards and defines best practices in almost every field of economic and social policy” (OECD).

Introduction to Innovation

One of the issues Per Frankelius, the Associate Professor at Örebro University detects, during his in depth survey for innovation, is that the common assumption suggests that the high-technology strategic knowledge for innovation is about technology.

And also that when referring to research and development for production or commercialisation, he believes that researches at all times is about the technology rather than economics, marketing, sociology, and neither about business administration nor about customer psychology.

Per believes that technology transfer and innovation does not need to be necessarily about technology. The best example to support this scenario, is the Columbia Accident Investigation Board’s statement about the Challenger shuttle’s tragedy in 1986. CAIB announced that the reasons behind the Challenger shuttle incident were rather caused by NASA's poor organizational culture and decision-making processes than technological issues (Admiral Harold Gehman 2003).

It is obvious that the organizational culture and decision-making processes are as important as innovation technologies in any section and project (Frankelius 2009). And also that the non-technological factors need to be treated as vital as the technological factors in the process of research and development.

Technology Transfer and innovation in Oil and Gas Supply Chain

Studying and analysing the oil and gas industry's supply chain can be complex and sometimes unclear. A supply chain strategy and policy for this industry, comprises the improvement of boundaries and parameters that controls the interactions between the clients and contractors. In saying that, this improvement occurs when two oil and gas companies join together to either purchase/provide products or services or both. Since in the oil and gas industry, one company's production is another company's input-for example, the output of drilling is the input to refineries-, oil and gas industry is an exceptional environment for development of what is called a vertical integration (Chima 2007).

However, regardless of how good the current supply chain of the oil and gas is, and how well the policies, strategies and technologies are placed, it still can be improved. "*Generally, oil and gas companies should view their supply-chain configuration and coordination systems as worthy of improvement*" (Chima 2007). Also, the same source believes that lack of improvement for any firm in this industry can lead to loss of competitive advantages.

On the other hand, improvement requires innovation especially in the operational environment. Operational innovation can simply be a different procedure in dealing with old problems. Close defines innovation as "*the invention of news ways of doing work*" (Chima 2007). Over years, oil and gas companies including the drilling sector, develop through merger, acquisition and business divergence. Whereas, growth, development and financial improvement can be achieved through innovation in the operation sector as well.

To discuss this further, we will have a look at the concept of technology transfer and innovation to see to what extent these concepts affect the industry.

The Concept of Technology Transfer

Anyone dealing with the concept of technology transfer, understands the complexity and the difficulty of defining and putting a boundary on the perception of “technology”. Moreover, streamlining the technology transfer process is practically impossible and gauging the influence of the transferred technology has been challenging the researchers forever (Bozeman 2000). However, the reason behind it, is that generally the technology transfer is somehow vastly meshed into the texture of all dimensions of the organisation, in a way that makes it hard to separate it from other organisation sectors.

The concept of technology transfer has been used widely by numerous faculties to define and analyse an extensive series of technology issues. First, referring to one of the most comprehensive definitions of technology transfer- based on the author’s opinion- by Roessner (2000) who says, “*Technology transfer is the formal and informal movement of know-how, skills, technical knowledge or technology from one organizational setting to another. The process often faces unfavourable economic incentives and an inadequate supply of complementary services to translate new ideas into technological and economically viable innovations. Coordination among various stakeholders is also a challenge. The technology transfer process requires access to a number of informational, financial, and human resources* “(Roessner 2000).

Conclusion

Based on the above mentioned definition, it seems that main hypothesis suggests the transformation of the traditional model of the technology transfer (which concentrated on the movement of a specific technology from one economic unit -such as department, lab, sector or country- to another economic unit- to another) to a modern approach. The necessity to improve, grow and expand the knowledge-based economy towards a more efficient system, the lack of transparency amongst operation and knowledge transfer, and lack of focus on vertical and horizontal organizational knowledge transfer, are profound invitations for the remodelling and reinterpretation of the basics of the technology transfer. It is clear that this perception affects and contributes to the area of innovation management as well.

The new focus on the innovation and technologies requires reassessment of the perceived barriers of technology transfer and innovation management, specifically recognition and examination of the different transfer contexts.

List of References:

'2014 global R&D funding forecast', 2013, *Battelle*, viewed December, <http://www.battelle.org/docs/tpp/2014_global_rd_funding_forecast.pdf>.

Acha, V & Cusmano, L 2005, 'Governance and co-ordination of distributed innovation processes: patterns of R&D co-operation in the upstream petroleum industry', *Economics of Innovation and New Technology*, vol. 14, no. 1-2, pp. 1-21, viewed 2015/09/09, <http://dx.doi.org/10.1080/1043859042000228651>.

Admiral Gehman H 2003, *Report of Columbia Accident Investigation Board*, NASA, NASA,<http://history.nasa.gov/columbia/Troxell/Columbia%20Web%20Site/Documents/Congress/Senate/SEPTEM~1/gehman_statement.html>.

Afuah, A 2012, *Innovation management: Strategies implementation & profits* Oxford University Press, New York.

Alan Bryman & Bob Burgess 1994, *Analyzing Qualitative Data*, First Edition edition edn, Routledge, London.

Allen, MC 2009, 'Germany's national innovation system', in *Encyclopedia of technology and innovation management*, Oxford, Blackwell, ch 375-389.

Angeles, R 2005, 'RFID technologies: supply-chain applications and implementation issues', *Information Systems Management*, vol. 22, no. 1, pp. 51-65, <http://dx.doi.org/10.1201/1078/44912.22.1.20051201/85739.7 http://www.tandfonline.com/doi/pdf/10.1201/1078/44912.22.1.20051201/85739.7>.

Austrade 2015, *Oil and gas to Singapore*, <http://www.austrade.gov.au/Export/Export-

Markets/Countries/Singapore/Industries/Oil-and-gas#.VYZbDzCqpBc>.

Australian Bureau of Statistics 2014, *Innovation in Australian business 2012-13* ABS, <http://www.abs.gov.au/ausstats/abs@.nsf/mf/8158.0#>.

Bagby, JW 1992, 'Public and industrial policy barriers to independent vertical integration: Reflections of Keiretsu', *Working Paper on the Law of Business Organizations*, p. 7.

Bass, C 2012, *The innovation and creativity*, viewed 20/10/2014, <http://www.talkmgt.com/blog/2012/05/24/carl-bass-the-innovation-and-creativity-connection-at-c2-mtl/>.

Bell, J, Frater, B, Butterfield, L, Cunningham, S, Dogson, M, Fox, K, Spurling, T & Webster, E 2014, *The role of science, research and technology in lifting Australian productivity*, http://www.acola.org.au/PDF/SAF04Reports/SAF04%20Role%20of%20SRT%20in%20lifting%20Aus%20Productivity%20FINAL%20REPORT.pdf>.

Blaustein, RS 2014, 'Comparative Innovation Strategies and Technology Transfer: U.S. Efforts', *US Department of Energy*, viewed 10 September 2014, <http://csis.org/files/attachments/100914_RBlaustein.pdf>.

Bloomberg 2014, created by Bloomberg, viewed January <http://images.businessweek.com/bloomberg/pdfs/most_innovative_countries_2014_011714.pdf>.

Bozeman, B 2000, 'Technology transfer and public policy: a review of research and theory', *Technology transfer; Public policy; Research; Theory*, pp. 1-3, <http://www.sciencedirect.com/science/article/pii/S0048733399000931>.

BP Statistical Review 2014, *Bp statistical review of world energy*, BPStats, London,<https://www.bp.com/content/dam/bp/pdf/Energy-

economics/statistical-review-2014/BP-statistical-review-of-world-energy-2014-full-report.pdf>.

British Petroleum 2013, *BP statistical review of world energy*, British Petroleum, London, June 2013, <http://www.bp.com/content/dam/bp/pdf/statistical-review/statistical_review_of_world_energy_2013.pdf>.

Brown, J 2015, 'Fueling the oil and gas supply chain', *Inbound Logistics*, July, (blog), viewed July 2014, <http://www.inboundlogistics.com/cms/article/fueling-the-oil-and-gas-supply-chain/>.

Cachon, GP 2004, 'The allocation of inventory risk in a supply chain: Push, pull, and advance-purchase discount contracts', *Management Science*, vol. 50, no. 2, pp. 222-38, <http://dx.doi.org/10.1287/mnsc.1030.0190>.

Chima, CM 2007, 'Supply-chain management issues in the oil and gas industry', *Journal of Business & Economics Research*, vol. 5, no. 6, pp. 28-36.

Chopra, S & Meindl, P 2007, *Supply chain management. Strategy, planning & operation*, 5th edn, Pearson Prentice Hall, Upper Saddle River, NJ.

Churchill, GA 1999, 'Marketing research: Methodological foundations', *Fort Worth, TX*.

Commission, P 2014, 'Pc productivity update 2014', <file:///C:/Users/W0076895/Desktop/Endnote%20Ref/productivity-update-2014.pdf>.

ConocoPhillips 2015, *Glossary of terms oil and gas*, <http://www.conocophillips.com/investor-relations/company-reports/Documents/PDF/SMID_392-COP-Glossary-of-Terms-External-

FINAL-5202013.pdf>.

Cummins, JG 2005, 'A new approach to the valuation of intangible capital', in *Measuring capital in the new economy*, University of Chicago Press, pp. 47-72.

Darwin City Council 2015, *About Darwin*, <http://www.darwin.nt.gov.au/live/about-darwin>.

David E. *Consuming Power: A Social History of American Energies.* The MIT Press: Cambridge, MA, 1999.

Department of Industry Tourism and Resources 2006, *Collaboration and other factors influencing innovation novelty in australian businesses*, http://www.industry.gov.au/innovation/reportsandstudies/Documents/CollaborationInnovationNovelty.pdf>.

Department of Natural Resources and Mines 2014, *About coal seam gas (CSG) and liquefied natural gas (LNG)*, https://www.dnrm.qld.gov.au/mining/coal-seam-gas/about/overview?SQ_DESIGN_NAME=print-guide>.

Dolgui, A & Proth, J-M 2010, *Supply chain engineering: useful methods and techniques*, Springer, London.

EBD 2015, *Energy*, Singapore Economic Development Board, <https://www.edb.gov.sg/content/edb/en/industries/industries/energy.html>.

National Oil Companies 2006, created by Economist, T, viewed Aug 10 <http://www.economist.com/node/7276986>.

Supermajordämmerung 2013, created by Economist, T, viewed Aug 3 <http://www.economist.com/news/briefing/21582522-day-huge-integrated-international-oil-company-drawing>.

Eurostat 2015, created by Eurostat, viewed January 20 <http://ec.europa.eu/eurostat/statistics-explained/index.php/File:Share_of_innovative_enterprises,_2010%E2%80%9312_(%C2%B9)_(%25_of_all_enterprises)_YB15.png>.

Fernand, A & Patrick, C 2001, 'Technology transfer revisited from the perspective of the knowledge-based economy', vol. 30, no. 9, pp. 1459-78, <http://www.sciencedirect.com/science/article/B6V77-44N9P3G-8/2/c67b03c316a69ba5e25d126d7c93d5ad>.

Fisher, ML 1997, 'What is the right supply chain for your product?', *Harvard Business Review*, vol. 75, no. 2, pp. 105-17.

Forbes 2013, *Innovation distinguishes between a leader and a follower*, Forbes.

*Exploiting unconventional oil fields requires overcoming tough logistics challenges 2014*a, created by Forbes, viewed January 1 <http://www.forbes.com/sites/stevebanker/2014/01/20/exploiting-unconventional-oil-fields-requires-overcoming-tough-logistics-challenges/>.

*The upstream shale oil supply chain 2014*b, created by Forbes, viewed Auggues 8 <http://www.forbes.com/sites/stevebanker/2014/08/08/the-upstream-unconventional-oil-gas-supply-chain/>.

Fox, MS, Chionglo, JF & Barbuceanu, M 1993, *The integrated supply chain management system*, Technical report, Department of Industrial Engineering, University of Toronto, Toronto, Ontario,<http://www.eil.utoronto.ca/wp-content/uploads/public/papers/iscm-intro.pdf>.

Frankelius, P 2009, 'Questioning two myths in innovation', *Journal of High Technology Management Research*, pp. 40-51, <http://www.academia.edu/3667333/Questioning_two_myths_in_innovation_

literature>.

Gardner, DL 2001, 'Logistics in the supply chain', *Traffic World*, vol. 265, no. 3, pp. 30-1, <http://connection.ebscohost.com/c/articles/8590033/logistics-supply-chain>.

Gibson, BJ, Mentzer, JT & Cook, RL 2005, 'Supply chain management: the pursuit of a consensus definition', *Journal of business logistics*, vol. 26, no. 2, pp. 17-25.

Gillham, B 2000, *The research interview*, Continuum Intl Pub Group.

Global Innovation Index 2013, 'The global innovation index 2013', *Global Innovation Index*, <http://www.wipo.int/edocs/pubdocs/en/economics/gii/gii_2013.pdf>.

Global survey of R&D tax incentives, 2014, Deloitte Touche Tohmatsu Limited, New York,<https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Tax/dttl-tax-global-rd-survey-aug-2014.pdf>.

Gray, J 2014, 'Optimizing the Supply Chain in Unconventional Oil and Gas – Part 2', *Evolve*, viewed May 22 2014, <http://evolve.cc/optimizing-the-supply-chain-in-unconventional-oil-and-gas-part-2>.

Group, WB 2014, *World development indicators* World Bank Publications, Washington <http://data.worldbank.org/sites/default/files/wdi-2014-book.pdf>.

Haskel, J & Westlake, S 2014, 'Look to the intangibles', *The Economist*, Feb 20th 2014.

Haworth, K 2010, 'All pipelines lead to Gladstone: Queensland's burgeoning LNG industry', *The Australian Pipeliner*, viewed July 2012,

<http://pipeliner.com.au/news/all_pipelines_lead_to_gladstone_queenslands_burgeoning_lng_industry/041805/>.

Hendrickson, L, Balaguer, A, Smith, R, Simpson, J, Wood, E, Drake, P, Alinejad, M, Brusse, S & Ford, A 2014, *Australian innovation system report 2014*, http://www.industry.gov.au/Office-of-the-Chief-Economist/Publications/Documents/Australian-Innovation-System/Australian-Innovation-System-Report-2014.pdf>.

Inkpen, AC & Moffett, MH 2011, *The global oil & gas industry: Management, strategy & finance*, PennWell Corporation, Tulsa, Oklahama.

Jeramy L. Patrik & Justin L. Helms 2006, *The book of action*.

Johnson, C 1982, 'Miti and the Japanese miracle', in *The Growth of Industrial Policy : 1925-1975*, Standford University Press, Standford, pp. 91-115.

Karyn Nair 2015, *Captains of industry champion oil and gas upstream technical advancements* Society of Petroluem Engineering <http://www.spe.org/events/apogce/2015/documents/15APOG-NewsRelease-5Mar.pdf>.

Kelly, G & La Cava, G 2014, *International trade costs, global supply chains and value-added trade in Australia*, Reserve Bank of Australia, http://www-dr.rba.gov.au/publications/rdp/2014/pdf/rdp2014-07.pdf>.

Lee, HL 2002, 'Aligning supply chain strategies with product uncertainties', *California Management Review*, vol. 44, no. 3, pp. 105-19, <http://cmr.ucpress.edu/content/44/3/15>.

Leedy, PD & Ormrod, JE 2005, 'Practical research', *Planning and design*, vol. 8.

Lehnfeld, M 2013, *Germany is europe's innovation incubator*, http://www.gtai.de/GTAI/Content/EN/Invest/_SharedDocs/Downloads/GTAI/BLG/blg-germany-innovation-incubator.pdf>.

Levi, MA, Economy, E, Shannon Kathleen, ON & Segal, A 2010, *Energy innovation: Driving technology competition and cooperation among the united states, china, india, and brazil*, Council on Foreign Relations, New York.

Lim, S & Strutt, A 1994, 'Japan's MITI : a role model for Australia and New Zealand?', pp. 23-6.

LOC 2006, *History of the Oil and Gas Industry*, The Library of Congress, <http://www.loc.gov/rr/business/BERA/issue5/history.html>.

Lockamy, A & McCormack, K 2004, 'The development of a supply chain management process maturity model using the concepts of business process orientation', *Supply chain management: An international journal*, vol. 9, no. 4, pp. 272-8, <http://dx.doi.org/10.1108/13598540410550019>.

Louis Galambos, Takashi Hikino & Zamagni, V 2007, 'The development of all-around chemical enterprises', in *The global chemical industry in the age of the petrochemical revolution*, Cambridge University Press, Cambridge, pp. 325-7.

Marc Lehnfeld 2013, *New challenges for germany in the innovation competition*.

Marien, EJ 2000, 'The four supply chain enablers', *Supply Chain Management Review*, vol. 2, no. 3, pp. 60-8, <http://www.scribd.com/doc/44639604/The-Four-Supply-Chain-Enablers#scribd>.

History of METI 2015, created by METI, http://www.meti.go.jp/english/aboutmeti/data/ahistory.html>.

Michaelides, D 2007, *The art of innovation: Integrating creativity in organizations*, Performa Productions, Ballaugh.

Michaelides, D 2012, *Innovation for competitive advantage*, <http://www.innovationexcellence.com/blog/2012/04/22/to-innovate-or-not-to-innovate-that-is-not-the-question/>.

Miller, T 2001, *Advanced manufacturing: hierarchical operations and supply chain planning*, Springer-Verlag, London.

Minichiello, V, Aroni, R & Hays, T 2008, *In-depth interviewing: Principles, techniques, analysis*, Pearson Education Australia.

Nikhil, J & Anand, P 2001, 'A generalized model of operations reversal for fashion goods', *Management Science*, vol. 47, no. 4, pp. 595-600, <http://dx.doi.org/10.1287/mnsc.47.4.595.9830>.

Norman K. Denzin, YSL 2000, *Handbook of qualitative research*, SAGE Publications.

Numbeo 2015, *Quality of Life Comparison Between Singapore and Darwin*, viewed 06/08/2015, <http://www.numbeo.com/quality-of-life/compare_cities.jsp?country1=Singapore&city1=Singapore&country2=Australia&city2=Darwin>.

OECD 2013a, *Science, technology and industry scoreboard 2013*, OECD, <http://www.oecd-ilibrary.org/docserver/download/9213051e.pdf?expires=1435983218&id=id&accname=guest&checksum=DC3CDB4B21B0BF498FADF988B083A035>.

*Hours worked 2013*b, created by OECD, https://data.oecd.org/emp/hours-worked.htm>.

OECD 2013c, *Hours worked* OECD, https://data.oecd.org/emp/hours-worked.htm>.

OECD 2013d, *Reviews of innovation policy innovation in Southeast Asia*, OECD.

OECD 2014, 'Policy challenges for the next 50 years', *OECD Economic Policy Paper*, no. 9, <http://oecd.mofa.go.kr/webmodule/common/download.jsp?boardid=11076&tablename=TYPE_LEGATION&seqno=00b057fedf8b03d007f98fb8&fileseq=037fb0fe8fdc050072063059>.

OECD 2015, *What makes us the OECD*, viewed 04/02/2015, <http://www.oecd.org/careers/whatmakesustheoecd.htm>.

OECD Development 2013, *OECD science, technology and industry scoreboard* Canongate US, Genev.

Pitman, MA & Maxwell, JA 1992, 'Qualitative approaches to evaluation: Models and methods', *The handbook of qualitative research in education*, vol. 729, p. 770.

Plunkett Corporation Ltd 2010, 'Transportation industry trends: introduction to the transportation & logistics industry', <www.plunkettresearch.com/Industries/TransportationSupplyChainLogistics/TransportationTrends/tabid/259/Default.aspx>.

Putz-Plecko, B 2008, 'Cultural education: The promotion of cultural knowledge, creativity and intercultural understanding through education', <http://dieangewandte.at/jart/prj3/angewandte/resources/dbcon_def/uploads/Universitaet/Berichte/EreportBparis0812.pdf>.

Roessner, JD 2000, *Science and technology policy in the us, a time of change*, Longman, London.

Ronald Oligney, Armando Izquierdo & Economides, M 2000, *The color of oil : The history, the money and the politics of the world's biggest business*, Round Oak Publishing Company, Texas.

Russell, KMaDW 1994, *Keiretsu: Inside the hidden Japanese conglomerates*, Mcgraw-Hill, New York.

Sarva, A 2014, *Why germans work fewer hours but produce more: A study in culture*, The Huffington Post, viewed 20/01/2015, <http://www.huffingtonpost.com/amol-sarva/why-germans-work-fewer-ho_b_6172262.html>.

SBS 2013, *Factbox: CSG in Australia*, SBS, <http://www.sbs.com.au/news/article/2013/03/12/factbox-csg-australia>.

Schilling, MA 2013, *Strategic management of technological innovation*, vol. 4th.

Schwengler, P & Freeth , G 2006, 'Automated tie-in technology for oil and gas pipeline construction', in *23rd World Gas Conference, June 5-9*: *proceedings of the23rd World Gas Conference, June 5-9* International Gas Union, Amsterdam, pp. 708-27, viewed <http://www.apia.net.au/wp-content/uploads/2010/06/Paper-04-Schwengler.pdf>.

Sherer, SA 2005, 'From supply-chain management to value network advocacy: implications for e-supply chains', *Supply Chain Management: An International Journal*, vol. 10, no. 2, pp. 77-83, <http://www.emeraldinsight.com/doi/pdfplus/10.1108/13598540510589151>.

Sichel, D 2005, *Measuring capital in the new economy. Studies in income and wealth*, National Bureau of Economic Research, University of Chicago Press.

Simchi-Levi, E & Kaminsky, D 2007, *Designing and managing the supply chain*. McGraw-Hill Education, New York City.

Singapore, PMsO 2015, *Statement by prime minister Lee Hsien Loong*, Prime Minister's Office Singapore, <http://www.pmo.gov.sg/mediacentre/statement-prime-minister-lee-hsien-loong>.

Soames, L, Brunker, D & Talgaswatta, T 2011, *Competition, innovation and productivity in Australian businesses*, Australian Bureau of Statistics, http://www.ausstats.abs.gov.au/Ausstats/subscriber.nsf/0/896C28E59CC4B822CA2579050014C578/$File/1351055035_sep%202011.pdf>.

Statistics, ABo, *Innovation in Australian business 2012-13 2013*, <http://www.abs.gov.au/ausstats/abs@.nsf/mf/8158.0>.

Statistics, ABo 2014, *Innovation in australian business*, Australian Bureau of Statistics, Canberra, 21 Jan 2015, <http://www.abs.gov.au/ausstats/abs@.nsf/mf/8158.0>.

Stephens, S 2001, 'Supply chain council & supply chain operations reference (scor) model overview', *Supply Chain Council, Inc., Pittsburgh, USA [http://www. supplychain. org/]*.

Supply chain management, logistics and supply chain segmentation. (2014). *Global Supply Chain*, 24-29.

The global innovation index 2013, *The global innovation index 2013: local dynamics of innovation*, Cornell University, INSEAD, and the World Intellectual Property Organization (WIPO), Geneva, Ithaca, and Fontainebleau,<http://www.wipo.int/edocs/pubdocs/en/economics/gii/gii_2013.pdf>.

Time and date 2015, *Distance calculator*, viewed 06/08/2015,

<http://www.timeanddate.com/worldclock/distanceresult.html?p1=236&p2=72>.

von Tunzelmann, N & Acha, V 2006, *Innovation in “low-tech” industries*, Oxford University Press 2006/01/19, <http://dx.doi.org/10.1093/oxfordhb/9780199286805.003.0015>.

White House 2011, *A strategy for american innovation: Securing our economic growth and prosperity*, 1234058901, White House, Washington,<https://www.whitehouse.gov/sites/default/files/uploads/InnovationStrategy.pdf>.

Wolf, R 2013, 'Management relations in the work culture in japan as compared to that of the west', *Innovative Journal of Business and Management*, pp. 116-22.

XE Currency 2013, *Xe currency charts (AUD/SGD)*, viewed 21 06 2015, <http://www.xe.com/currencycharts/?from=AUD&to=SGD&view=5Y>.

Yi, T 2010, *The oil and gas service industry in Asia: a comparison of business strategies*, Palgrave Macmillan.

Yin, RK 2013, *Case study research: Design and methods*, Sage publications.

Yusuf, YY, Gunasekaran, A, Adeleye, EO & Sivayoganathan, K 2004, 'Agile supply chain capabilities: Determinants of competitive objectives', *European Journal of Operational Research*, vol. 159, no. 2, pp. 379-92, <http://ac.els-cdn.com/S0377221703005241/1-s2.0-S0377221703005241-main.pdf?_tid=53df25ee-1fa8-11e5-9fa7-00000aab0f02&acdnat=1435724532_23d4690f66440920893264cc722f8da4>.

Appendix 8: Submitted to the Australian Journal of Mechanical Engineering

Elsevier Editorial System(tm) for Energy Strategy Reviews
Manuscript Draft

Manuscript Number: ESR-D-15-00107

Title: Comparative analysis of Australian Innovation and the tyranny of distance

Article Type: General ESR Issue

Keywords: Comparative analysis; Australian Innovation; top 20 countries

Corresponding Author: Mr. Daniel Davoodian,

Corresponding Author's Institution:

First Author: Daniel Davoodian

Order of Authors: Daniel Davoodian; Steven Goh

Abstract: Oil and gas industry as the largest and most influential industry has its own strategies and policies. However, managing innovation and technology transfer in supply chain network of oil and gas, has become an imperative for every company to reach economic success. Nevertheless, in order to understand the trend of innovation in Australian drilling industry, it is required to have an in depth understanding of the innovation system in Australia. This paper covers a discussion about innovation in Australian oil and gas and the comparative analysis of Australian position in global index with other innovative countries. The paper also discuss the issue of geographical position as the barrier of innovation and technology transfer.

Suggested Reviewers: Tatiana Mitrova
mitrovat@me.com

Stacy Closson
stacy.closson@uky.edu

Adam Stulberg
adam.stulberg@inta.gatech.edu

title page.doc

Title: Comparative analysis of Australian Innovation and the tyranny of distance

First Author	Mr Daniel Davoodian
University	University of Southern Queensland
Faculty or Centre	Health, Engineering and Sciences
Campus	TOOWOOMBA
Email	Davoodian.d@gmail.com
Mobile	+61 422 606 389

Second Author	Dr Steven Goh
University	University of Southern Queensland
Faculty or Centre	Health, Engineering and Sciences
Campus	TOOWOOMBA
Email	Steven.goh@usq.edu.au
Phone	+61 746 311 446

cover letter.doc

Hi,

This is just to confirm that this work has not been submitted previously to Energy Strategy Reviews(in part or in whole), that it has not been published previously and is not under consideration for publication elsewhere, and is approved by all authors and host authorities.

Thank you.

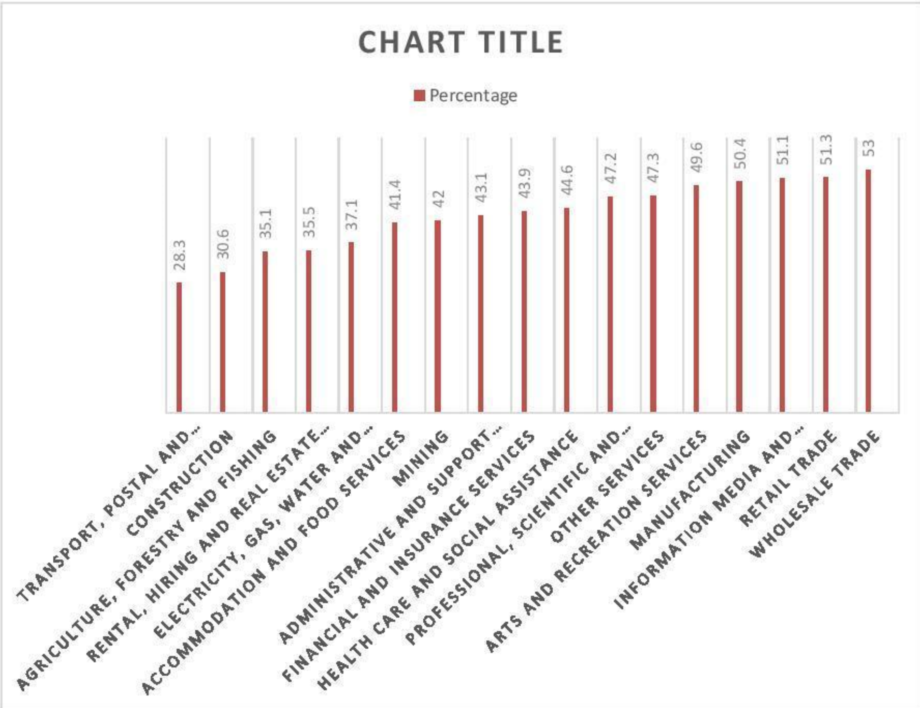
Daniel Davoodian
Email: davoodian.d@gmail.com
Tel: 0422 606 389

- Oil and gas industry as the largest and most influential industry has its own strategies and policies
- Managing innovation and technology transfer in supply chain network of oil and gas, has become an imperative for every company to reach economic success
- The issue of geographical position as the barrier of innovation and technology transfer in Australia is a myth

Introduction

Before reviewing the empirical evidences provided by the Australian Bureau of Statistics, I would like to point out the definition that these figures are based on. "*The development or introduction of new or significantly improved goods, services, processes or methods is generally considered to be innovation*". According to this definition, the bar is not set too high for any company to be considered innovative in Australia (2014).

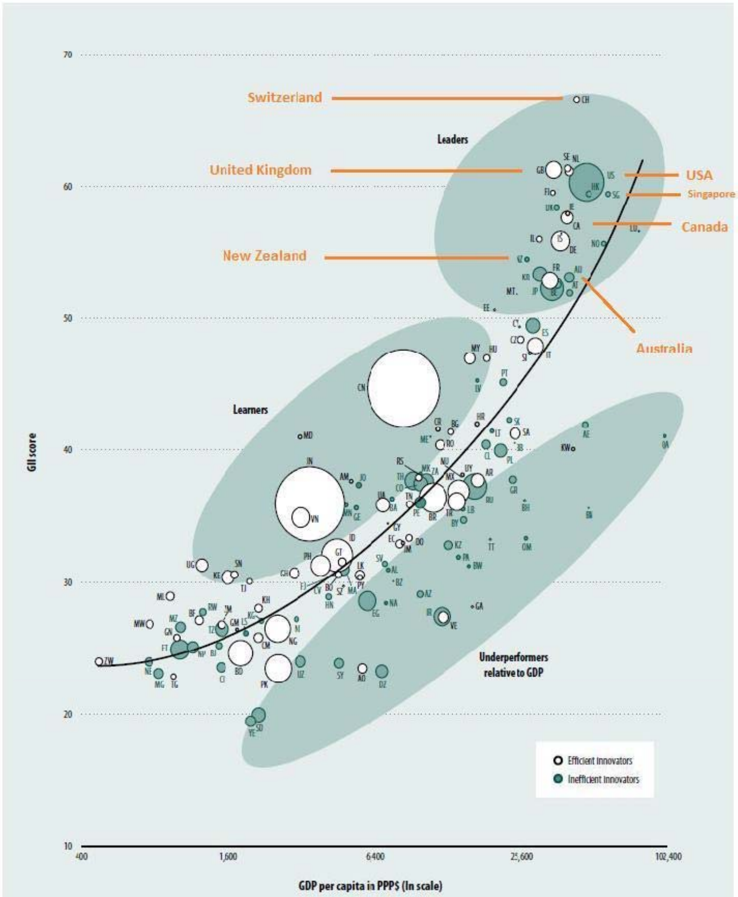
However, although the definition provided by ABS seems to be too general, only less than half of the Australian businesses are involved in any innovative activities (Index1). Specifically in the mining industry-including the drilling sector- only 42% of companies have been involved in any sort of innovation activities-Index A.



Index A: Innovation in Australian Business(2014)

This means that the local trend of innovation in Australia does not look strong enough. The author emphasises that according to the above mentioned definition, adopting and using innovation and technology transfer by local industries in Australia is also poor. The story does not finish here. In order to be sure that the right issue is being addressed, we look at the Australia's position in the world of innovation according to the global innovation index.

Australia is 19th on the global scale and it is located at the bottom of the list of the top 20 countries-Index B-(2013). This scale shows that amongst top 20 countries, Australia does not seem to be doing very well. This seems to be quite a significant factor in addressing the current issues in transfer of technology from and to Australia.



Index B: GII scores and GDP per capita in PPP$ -bubbles sized by population-(2013)

Conversely, having a quick look at the possible barriers of the technology transfer, it seems that unclear government innovation policy measurement and lack of industry innovation trend are the major barriers. It is not far from the truth to mention that, the low rate of innovation and the geographic position also highly contributes to the absence of international technology and innovation owners in the Australian market.

However, as the purpose of this paper is to compare Australia's innovation situation with successful innovative countries who are in a higher ranking position. To perform our comparative analysis, we need to inspect the reasons behind the exiting facts and the current innovation culture of the country. Consequently, in order to compare the Australia's current innovation system with successfully innovative countries, it is decided to select two top level performers of global innovation index and OECD index. Two countries of Germany-5th innovative- and Japan-4th innovative- as leaders of innovation at the global level, have been chosen to be investigated for the reasons behind their innovation success

Germany and Japan both have been well known for their platform and one of the best models of innovative countries amongst innovation leaders. Few research papers have suggested that most emerging economies, use Germany or Japan as the role at the core of their innovation system. But to what extend and which countries have chosen Japan and Germany as best practice of innovation system is beyond this paper's boundaries.

German innovation system

Germany as the largest national economy in EU, has increased their funding in research system and particularly in the energy industry. As the result, research and development in private sector, university and government are also boosted up (Matthew 2009) Reading through top country's innovation system, Germany seems to be offering one of the best platforms of innovation to big economies. To what extend other countries used German's innovation system, is beyond this paper's boundaries.

Public financial aid in Germany, is either project based or comes in form of institutional funding. Therefore, innovation projects are either received as the support for an individual or research institution fund aid. In addition, currently, the tax incentives scheme for research and development institutions is being discussed which the outcome is not confirmed yet. (*Global Survey of R&D Tax Incentives* 2014)

Eurostat's scoreboard shows, Germany has spent nearly as 74 billion euro (Almost 84.5 billion USD) on R&D, more than any other European country, between 2010 and 2012 (2015).

Germany's leadership in innovation in the world and specifically amongst European countries is quite rich (Lehnfeld 2013). In 2012 Germany's gross expenditure on R&D is raised to 94 billion USD while Japan's budget was 160 billion USD, United State has spent 447 billion. Australia's gross expenditure on research and development on the same year was only 22 billion USD. As some may argue that the R&D should be compared by GDP; it must be mentioned that Germany has a positive rank in research and development divided by GDP as well (Appendix A).

This means that the extraordinary funding backup is not the only significant factor for Germany's success. However, innovation superiority seems to be, not only the government's mission, but it is also supported by basic law and "habit".(Kroll 2008) Habit or better to say, German's work ethic is the reason why, Germans work fewer hours but produce more. It is obvious that German employees work less than Australians but being more innovative in those hours than Australians (Hours Worked 2013). Working hours mean working hours (Sarva 2014).

Japanese Culture: Tradition, Loyalty and Innovation

Before discussing the Japanese innovation system, it is essential to understand the historic motives of energy innovation in this country. As many may guess, MITI will be the first to talk about. MITI, the Ministry of International Trade and Industry before the reform of 2001 and merging with other agencies -the name is change to METI, Ministry of Economy, Trade and Industry- but as the foundation of industry policy of Japan. (2015)

METI, has dictated the internationalization, modernisation and technology procurement and investment guide for Japan. MITI's foreign competitive policies, has highly emphasised on R&D section of the policy, and indeed left a watermark on innovation culture of Japan. (Johnson 1982)Although many, such as Mr Steven Lim may argue that "*Japan's success may be despite, rather than because of MITI*"(Lim & Strutt 1994), the vital role of MITI in today's Japanese Innovation and R&D success is not easy to ignore.

Another unforgettable element in today's Japanese successful policies is the occurrence of Keiretsu structure. This unique phenomenon was developed during the post-war era, to create an interlocking business relationship between major Japanese giants; both as financial Keiretsu and industrial Keiretsu.(Russell 1994) Misubishi Chemical (Louis Galambos 2007) is one the famous example of the vertically integrated Keiretsu firm where you have everything in the supply chain knitted out into Misubishi Chemical.

But the advantages of Keiretsu system is not only limited to the financial security. Keiretsu public and industrial policy creates a barriers against adverse international market competitions and takeovers. Technology transfer and knowledge transfer between Keiretsu members brings a larger pool of knowledge. They share the results of research and development to learn technology through their relationship. This mesh of integrated knowledge relationship, creates a foster linkage between the technology leaders of the group and smaller suppliers in knowledge transfer, as well as forming an exclusive affiliation to form an integrated supply framework and an integrated distributor framework (Bagby 1992).

Another eminent factor in Japanese innovation success, seems to be Japanese working philosophy. Although long working hours will be discussed as a sin by some, work is a privilege, not an obligation in Japanese culture. Needless to mention, Japanese management approach, involves the team leader to pay attention to the needs of team members, both personal wellbeing and professional needs (Wolf 2013).

Although there are few more elements for prosperity of Japanese and Germany in innovation and technology transfer to mention, government policy, innovation culture and working culture appeared to be most considerable factors behind their success, to placed them both above Australia's position in global rankings, by far .

Speaking to more than 30 industry leaders and managers, more than 62% mentioned Australia's geographical position as a one of the most vital barriers of technology transfer and innovation. But to what extend this index affects the innovation and tech-transfer is the question of this sector of the paper. By a quick look at the global innovation index, there are three countries of Japan, South Korea and Singapore seem to be having almost the same distance from West Europe and US, as the big markets and exporters of innovation and technology.

Japan, however relevant or irrelevant, is covered in the previous chapter for other reasons. Between these two countries, the author has decided to choose Singapore as the most interesting case. The island state with no oil or gas resource, being the oil and gas hub of a region as well as being one of the most innovative nations owning the most high-tech manufacturing lines in the world (Yi 2010).

Singapore

At the end of the day, what have I got?
A successful Singapore.
What have I given up? My life

Lee Kuan Yew, the founder of modern Singapore

Singapore does not have any oil and gas reserves. Singapore surprisingly does not have any drilling activity either and like Japan, it imports considerable amount of oil and gas (Yi 2010). But shockingly, Singapore is indeed the oil and gas hub of the region.

OECD in their publication of Innovation in Southeast Asia, specifies one of the significant reasons behind Singapore's hasty growth as being the industrial

restructuring and constant technological upgrading (OECD 2013). Another mentioned vital index for growth seems to be the public policy to encourage openness in their overseas collaboration. Third significantly effective key factor seems to be ease of entering and investing in Singapore.

Facts and figures mentioned by the energy industry of Singapore indicates that Singapore has one of the strongest equipment and oil rig manufacturing sectors in the world (EBD 2015). 95% of major oil and gas company's headquarters are located in Singapore as well being home to Keppel and Sembcorp Marine, largest rig manufacturing companies in the globe (Austrade 2015).

60% of all global oilfield equipment manufacturers have a manufacturing line in Singapore. Some may argue that the Australian high dollar value is the main reason behind the poor manufacturing system. Needless to mention that, as the below chart shows, Australian dollar and Singaporean dollar were not that different in value in the past decade. Above and beyond this, Singapore has the world's largest single bunkering port, the third largest refining centre after US Gulf Coast, North West Europe (BP Global 2014).

SGD per 1 AUD, 9 Aug 2005 00:00 UTC – 6 Aug 2015 07:17UTC
AUD/SGD close 1.01382 low: 0.91252 high: 1.35707

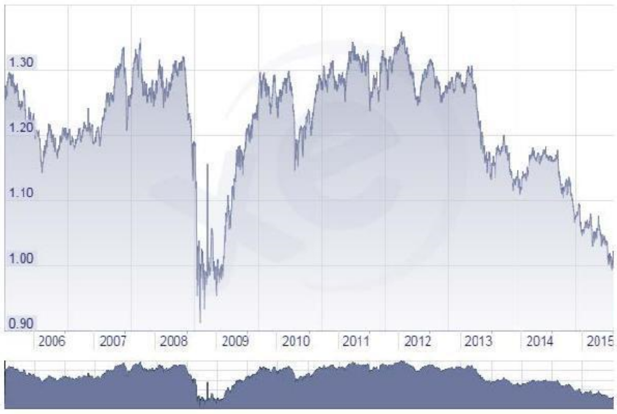


Chart A: Currency Chart AUD/SGD (Currency 2013)

As the Global Innovation Index ranking indicates, Singapore has improved from the position of 8th in 2013 to position 7th in 2014.

The Law of Attraction

In order to be a bit more accurate in our comparative analysis, it is fair to compare Singapore with an oil and gas city in Australia. However, Darwin seems to be geographically the closest oil and gas city of Australia to Singapore, with the distance of 3348 kilometres or 1808 nautical miles from Singapore (date 2015).

Needless to mention that the comparative technical analysis of the difference between Singapore and Darwin such as shipping line, bunkering, marine etc is beyond boarders of this paper. Regardless, the author has used other indexes to compare these two cities.

Darwin as Australia's most cosmopolitan city (Council 2015), has a highier quality of life 222.84, in compare with Singapore with 150.01 score. While the safety index of Singapore remains very high, Darwin's safety index is moderate. Health care index of Darwin is at moderate level while Singapore's is high. But above and beyond these, property price, and traffic commute time index as well as the population indexes, are significantly lower that Singapore; which seems to more relevant to manufacturing and operation sectors(date 2015).

Consequently, it is obvious that although the long distance may contribute to barriers of innovation and technology transfer, the tyranny of distance is not necessarily the main cause of the barriers.

However, this question remains unanswered that what can be do in order to turn Darwin into a more attractive choice for the oil and gas industry. And what are the barriers that stopping Darwin from being the hub of oil and gas of Asia?

FORECAST GROSS EXPENDITURES ON R&D

		2012			2013			2014		
		GDP PPP Bil, US$	R&D as % GDP	GERD* PPP Bil, US$	GDP PPP Bil, US$	R&D as % GDP	GERD PPP Bil, US$	GDP PPP Bil, US$	R&D as % GDP	GERD PPP Bil, US$
1	United States	15,940	2.8%	447	16,195	2.8%	450	16,616	2.8%	465
2	China	12,610	1.8%	232	13,568	1.9%	258	14,559	2.0%	284
3	Japan	4,704	3.4%	160	4,798	3.4%	163	4,856	3.4%	165
4	Germany	3,250	2.8%	92	3,266	2.8%	92	3,312	2.9%	92
5	South Korea	1,640	3.6%	59	1,686	3.6%	61	1,748	3.6%	63
6	France	2,291	2.3%	52	2,296	2.3%	52	2,319	2.3%	52
7	United Kingdom	2,375	1.8%	43	2,408	1.8%	44	2,454	1.8%	44
8	India	4,761	0.9%	40	4,942	0,85%	42	5,194	0.9%	44
9	Russia	2,555	1.5%	38	2,593	1.5%	38	2,671	1.5%	40
10	Brazil	2,394	1.3%	30	2,454	1.3%	31	2,515	1.3%	33
11	Canada	1,513	1.9%	29	1,537	1.9%	29	1,571	1.9%	30
12	Australia	987	2.3%	22	1,012	2.3%	23	1,040	2.3%	23
13	Taiwan	918	2.3%	21	938	2.3%	22	974	2.4%	23
14	Italy	1,863	1.3%	23	1,829	1.2%	22	1,842	1.2%	22
15	Spain	1,434	1.3%	19	1,415	1.3%	18	1,418	1.3%	18
16	Netherlands	719	2.0%	15	710	2.1%	15	712	2.1%	15
17	Sweden	399	3.4%	14	403	3.4%	14	412	3.4%	14
18	Israel	253	4.3%	11	263	4.2%	11	271	4.2%	11
19	Switzerland	369	2.9%	11	375	2.9%	11	382	2.9%	11
20	Turkey	1,142	0.9%	10	1,185	0.9%	10	1,227	0.9%	11
21	Austria	365	2.8%	10	366	2.8%	10	372	2.8%	10
22	Singapore	332	2.6%	9	344	2.6%	9	355	2.7%	9
23	Belgium	427	2.0%	9	427	2.0%	9	432	2.0%	9
24	Iran	1,016	0.8%	8	1,001	0.8%	8	1,014	0.8%	9
25	Mexico	1,788	0.5%	8	1,809	0.5%	8	1,864	0.5%	8
26	Finland	201	3.8%	8	200	3.6%	7	202	3.5%	7
27	Poland	814	0.8%	6	825	0.8%	6	844	0.8%	7
28	Denmark	214	3.1%	7	214	3.0%	6	217	2.9%	6
29	South Africa	592	1.0%	6	604	1.0%	6	621	1.0%	6
30	Qatar	191	2.8%	5	201	2.8%	6	211	2.7%	6
31	Czech Republic	292	1.8%	5	291	1.8%	5	295	1.8%	5
32	Argentina	755	0.6%	5	781	0.6%	5	803	0.6%	5
33	Norway	282	1.7%	5	287	1.7%	5	293	1.7%	5
34	Malaysia	507	0.8%	4	531	0.8%	4	557	0.8%	5
35	Pakistan	524	0.7%	4	543	0.7%	4	556	0.7%	4
36	Portugal	251	1.5%	4	246	1.5%	4	248	1.4%	4
37	Ireland	195	1.8%	3	196	1.7%	3	200	1.7%	3
38	Saudi Arabia	922	0.3%	2	955	0.3%	3	997	0.3%	3
39	Ukraine	341	0.9%	3	341	0.9%	3	348	0.9%	3
40	Indonesia	1,237	0.1%	2	1,303	0.2%	2	1,374	0.2%	3
Subtotal (Top 40)		**73,362**	**2.0%**	**1,478**	**75,338**	**2.0%**	**1,518**	**77,896**	**2.0%**	**1,576**
Rest of World		**10,071**	**0.4%**	**39**	**10,413**	**0.4%**	**40**	**10,837**	**0.4%**	**42**
Global Spending		**83,434**	**1.8%**	**1,517**	**85,751**	**1.8%**	**1,558**	**88,733**	**1.8%**	**1,618**

*** GERD = Gross Expenditures on Research and Development**
PPP= Purchasing Power Parity (used to normalize)

Source: Battelle, *R&D Magazine*, International Monetary Fund, World Bank, CIA Fact Book

Appendix A: ('2014 Global R&D Funding Forecast' 2013)

References:

'2014 Global R&D Funding Forecast', 2013, *Battelle*, viewed December, <http://www.battelle.org/docs/tpp/2014_global_rd_funding_forecast.pdf>.

Austrade 2015, *Oil and gas to Singapore*, <http://www.austrade.gov.au/Export/Export-Markets/Countries/Singapore/Industries/Oil-and-gas#.VYZbDzCqpBc>.

Australian Bureau of Statistics 2014, *Innovation in australian business 2012-13* ABS, <http://www.abs.gov.au/ausstats/abs@.nsf/mf/8158.0#>.

Bagby, JW 1992, 'Public and industrial policy barriers to independent vertical integration: Reflections of Keiretsu', *Working Paper on the Law of Business Organizations*, p. 7.

BP Statistical Review of World Energy 2014, 2014, created by BP Global, viewed June <file:///C:/Users/W0076895/Desktop/BP-statistical-review-of-world-energy-2014-full-report.pdf>.

Cornell University, INSEAD & WIPO 2013, *The Global Innovation Index 2013: local dynamics of innovation*, Cornell University, INSEAD, and the World Intellectual Property Organization (WIPO), Geneva, Ithaca, and Fontainebleau,<http://www.wipo.int/edocs/pubdocs/en/economics/gii/gii_2013.pdf>.

Council, DC 2015, *About Darwin*, <http://www.darwin.nt.gov.au/live/about-darwin>.

Currency, X 2013, *XE Currency Charts (AUD/SGD)*, viewed 21 06 2015, <http://www.xe.com/currencycharts/?from=AUD&to=SGD&view=5Y>.

date, Ta 2015, viewed 06/08/2015, <http://www.timeanddate.com/worldclock/distanceresult.html?p1=236&p2=72>.

EBD 2015, *Energy*, Singapore Economic Development Board, <https://www.edb.gov.sg/content/edb/en/industries/industries/energy.html>.

Eurostat, 2015, created by Eurostat, viewed January 20 <http://ec.europa.eu/eurostat/statistics-explained/index.php/File:Share_of_innovative_enterprises,_2010%E2%80%9312_(%C2%B9)_(%25_of_all_enterprises)_YB15.png>.

Global Survey of R&D Tax Incentives, 2014, Deloitte Touche Tohmatsu Limited,, New York,<https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Tax/dttl-tax-global-rd-survey-aug-2014.pdf>.

2013, created by Hours Worked, https://data.oecd.org/emp/hours-worked.htm>.

Johnson, C 1982, 'Miti and the Japanese Miracle', in *The Growth of Industrial Policy : 1925-1975*, Standford University Press, Standford, pp. 91-115.

Kroll, RFaH 2008, *New Challenges for Germany in the Innovation Competition.*

Lehnfeld, M 2013, 'Germany Is Europe's Innovation Incubator', *Germany Trade & Invest*, <http://www.gtai.de/GTAI/Content/EN/Invest/_SharedDocs/Downloads/GTAI/BLG/blg-germany-innovation-incubator.pdf>.

Lim, S & Strutt, A 1994, 'Japan's MITI : a role model for Australia and New Zealand?', pp. 23-6.

Louis Galambos, TH, Vera Zamagni 2007, 'The development of all-around chemical enterprises', in *The Global Chemical Industry in the Age of the Petrochemical Revolution*, Cambridge University Press, Cambridge, pp. 325-7.

Matthew, DA 2009, 'Germany's National Innovation System', in *Encyclopedia of Technology and Innovation Management*, Oxford, Blackwell, pp. 375-89.

History of METI, 2015, created by METI, http://www.meti.go.jp/english/aboutmeti/data/ahistory.html>.

OECD 2013, *Reviews of innovation policy innovation in southeast asia*, OECD.

Russell, KMaDW 1994, *Keiretsu: Inside the Hidden Japanese Conglomerates*, Mcgraw-Hill, New York.

Why Germans Work Fewer Hours But Produce More: A Study In Culture, 2014, created by Sarva, A, viewed November 18 <http://www.huffingtonpost.com/amol-sarva/why-germans-work-fewer-ho_b_6172262.html>.

Wolf, R 2013, 'Management Relations in the work culture in Japan as compared to that of the West', *Innovative Journal of Business and Management*, pp. 116-22.

Yi, T 2010, *The oil and gas service industry in Asia: a comparison of business strategies*, Palgrave Macmillan.