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Exploring open innovation maturity in a slow clock-speed context: evidence from the oil and gas industry

by

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Copyright Statement

Signed: _____

Stuart MacKinven

Date: _____

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List of Acronyms

CEO – Chief Executive Officer

E&P – Exploration and production

EurOMA – European Operations Management Association

IP – Intellectual property

IS – Information systems

JV – Joint venture

KE – Knowledge exchange

KTP – Knowledge Transfer Partnership

NIH – Not invented here

NPD – New product development

NSH – Not sold here

NSRI – National Subsea Research Initiative

OECD – Organisation for Economic Co-operation and Development

OGA – Oil & Gas Authority

OGIC – Oil and Gas Innovation Centre

OI – Open innovation

OIMM – Open Innovation Maturity Model

P&G – Procter and Gamble

R&D – Research and development

SE – Scottish Enterprise

SME – Small and medium-sized enterprise

TLB – Technology Leadership Board

UK – United Kingdom

Abstract

Open innovation has been positioned as the new imperative for creating and profiting from technology (Chesbrough, 2003). However, there are a number of unanswered questions surrounding this new research paradigm. The theoretical issue is trying to understand what open innovation is and how this is different from other forms of innovation. There is also the industrial problem of companies wanting to become better at open innovation but do not understand enough about it to make the transition. In addition, evidence suggests that firms' strategic decisions in fast paced industries often differ from those in slow-paced industries (Noke et al., 2008). Therefore, the first stage in this research necessitated an exploration into existing literature and theory on open innovation and innovation more generally. This suitably provided the necessary knowledge to investigate how companies currently engage in open innovation, and assess whether or not there has been a paradigm shift towards open innovation as initially claimed, and to what extent industry clock-speed (Fine, 1998) impacts on an organisations strategic open innovation activity.

This study adopted a deductive approach to research by developing an open innovation maturity model based on a literature review to explore how firms in slow clock-speed industries engage in open innovation. Using a mixed methods research design, this study was able to gather rich qualitative data on three core open innovation activities, as well as subjective numerical data to provide a metric towards open innovation maturity. Specifically, this research investigates open innovation maturity in the oil and gas industry. Throughout the data collection process, it became possible to gain a deeper understanding for how companies address these innovation activities. Moreover, it has ultimately enabled the ability to question the extent to which open innovation has been adopted in a slow clock-speed setting.

This research finds that companies in slow clock-speed industries operate with varying degrees of openness, intuitively use external knowledge, and benefit from using many of the 'modes of open innovation' as expressed by Bianchi et al. (2010). However, there is very little evidence to suggest that this is objectively directed towards implementing open innovation as a mode of operation. Furthermore, for the firms who communicate that they engage in open innovation, they are yet to show evidence of internal organisational transformation and management of OI activities. Therefore, this thesis has shown ability for academics to observe practices of open innovation from a distance and cite that the firm is engaged in open innovation, but fail to ask how the company has transformed itself to reflect open innovation through organisational culture, business processes, individual roles, and performance measurement of key open innovation activities. Crucially, companies do not need to do open innovation to be successful; the key is in their level of maturity for innovation processes. Comparing these findings to the strategic framework proposed by Miles and Snow (1978), it is possible to see that a more closed approach to innovation prevails when adopting the Defender position, while a more open approach occurs when assuming a Prospector position (Bader and Enkel, 2014).

For companies that are interested in reaching a professional level of open innovation, this study identifies a number of capabilities required for successful open innovation. In addition, the research proposes a Model of Strategic Open Innovation Adoption, highlighting open innovation as a process. This thesis contributes to academic understanding of OI by noting its difference from traditional forms of innovation by its explicit focus on communicating the complimentary nature of external knowledge on internal developments.

Appended papers

Paper 1: MacKinven S, MacBryde J, Wagner B. 2013. A framework for measuring open innovation maturity levels. Paper presented at the *20th EurOMA Conference: Operations Management at the Heart of the Recovery*, Dublin, Ireland

Paper 2: MacKinven S, MacBryde J, Wagner, B. 2014. Open Innovation Management through Strategic Implementation. Paper presented at the *R&D Management Conference,* Stuttgart, Germany

Paper 3: MacKinven S, MacBryde J. Wagner, B. 2014. Sensing opportunities: Is there a need for a managed search process in open innovation? Paper presented at the *21st EurOMA Conference: Operations Management in an Innovation Economy,* Palermo, Italy

Paper 4: MacKinven S. 2015. Modelling the Strategic Adoption of Open Innovation for Improved Decision-Making. Paper presented at the *27th European Conference on Operational Research,* Glasgow, Scotland

Chapter 1. Introduction

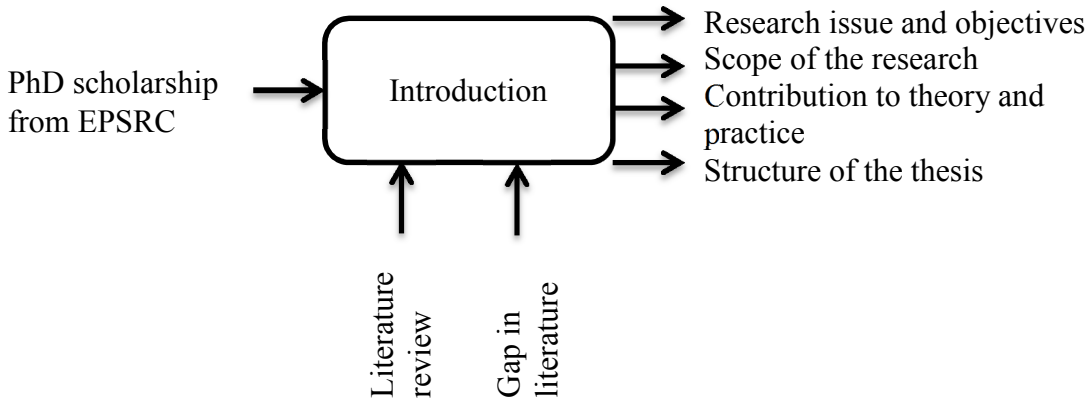


Figure 1: Chapter 1 input - output diagram

The purpose of this thesis is not to advocate that companies should do open innovation, but it is an investigation into how companies are currently pursuing open innovation activities. As noted by Birkinshaw et al. (2011), 'open innovation is not the future, but it is certainly part of the future.' Moreover, this thesis takes an unbiased approach to the research, with no favour for or against open innovation, and the study is simply motivated by a desire to identify key areas for firms who are interested in improving their capability in open innovation. This chapter explores the rationale for examining how firms in a slow clock-speed industry context currently engage in open innovation, particularly with the idea that adopting a process perspective can assist firms to improve their open innovation capability. The chapter considers the issue of understanding the key factors associated with firms becoming better at open innovation in the pursuit of advancing theory and practice, which is reflected in the aim and objectives of this study. In order to tackle this problem, the scope and research approach is discussed.

This thesis takes the stance that there is a need to measure current open innovation maturity as a precursor to understanding how firms strategically operate by open innovation, as this should give a more representative account of a firm's adoption of open innovation. As noted by Bader and Enkel (2014), a firm's strategy is likely to be an indicator towards the degree of openness shown by an individual business. The driver for measuring open innovation maturity is to critically assess and to comparatively test how companies compare to what existing literature says about open innovation. By doing so, it provides an ability to reveal the extent to which companies have addressed and purposefully manage open innovation within their organisation. A recent special issue in *Research Policy* jointly written by Joel West, Ammon Salter, Wim Vanhaverbeke, and Henry Chesbrough indicated that there is a need for better approaches to measuring open innovation (West et al., 2014). Consequently, this research takes into account the call made by Richard et al. (2009) for theoretically grounded performance measures. At this moment in time there are limited ways in which firms can measure open innovation performance (Enkel and Lenz, 2009), with the exception of (Enkel et al., 2011). Also, the degree of

information relating to how a firm may effectively pursue open innovation is similarly inadequate.

Taking inspiration from Mendibil (2003), each chapter of this thesis will begin with an input-output diagram, exampled by figure 1 above. The purpose of the diagrams is to illustrate and outline the content of the immediate chapter. The left hand side of the diagram represents the inputs, the right hand side shows the outcomes, and the writings underneath the diagram denote the action performed to help facilitate the overall process. The following text in this section subsequently provides background information on innovation in the lead up to the thesis aim.

1.1 Point of departure

Firms are increasingly recognising the importance of innovation as a means to sustained competitive advantage (Teece et al., 1997) and survival (Drucker, 1994). However, despite innovation being such an important feature of a company's operations, there is still no universally accepted way, or blueprint in which to effectively measure innovation performance. This is largely down to the fact that it is not a straightforward task (Bititci et al., 2012). Particularly for open innovation, there are limited ways to measure its performance (Enkel et al., 2011). This is especially relevant for those firms who are interested in managing open innovation activity (Spithoven et al., 2012). Given the increased research focus on organisational collaboration for innovation (Chesbrough and Garman, 2009; Mendibil et al., 2013), there is demand for research into performance measurement in supply chains and collaborative organisations (Bititci et al., 2012).

Due to open innovation's wide popularity in policy and management literature on technology and innovation (Huizingh, 2011; Hsieh and Tidd, 2012), it has been recognised that there is an academic need to better understand how companies have transformed themselves to operate using open innovation as a mode of operation. Literature confirms that open innovation involves significant organisational changes and the redefining of tasks and boundaries inside the firm (Van de Vrande and de Man, 2011; Alexy et al., 2013). Moreover, the need from industry is driven by their aspirations of improving their open innovation capability. Therefore, this research begins by realising a desire for theoretically grounded research that measures organisational performance (Richard et al., 2009) through an open innovation lens (Chesbrough, 2003). Therefore, this study moves beyond popular measures of innovation such as R&D expenditure, patent counts, and new product introductions (Hagedoorn and Cloodt, 2003), and instead, seeks to provide a means for firms to assess their strategic adoption of open innovation.

There is a long-standing history of firms developing new products and services in-house through the utilisation of knowledge acquired from the external environment (Freeman, 1991). However, findings from the OECD (2008) still show that despite an uptake in external ideas, the vast majority of R&D expenditure is focused on in-house projects. Therefore, although firms have been involved in 'open innovation activity' from all times, as evidenced as far back as 19th Century England during iron production (Allen, 1983), there is still a requirement to explore how firms have embraced the open innovation model. This research attempts to study and measure open innovation maturity (West et al., 2014) by looking for evidence of a managed process towards OI (MacKinven et al., 2014b).

1.2 Thesis aim

Outlining the research issue and objectives represents one of the most critical aspects of any research project. According to Yin (2003), research should begin with a set problem or issue that requires further investigation. The main issue surrounding this

research is how can firms become better at open innovation. Therefore, the overall aim of the research was to:

> **Understand how the velocity of change in the external business environment impacts firms' strategic open innovation orientation.**

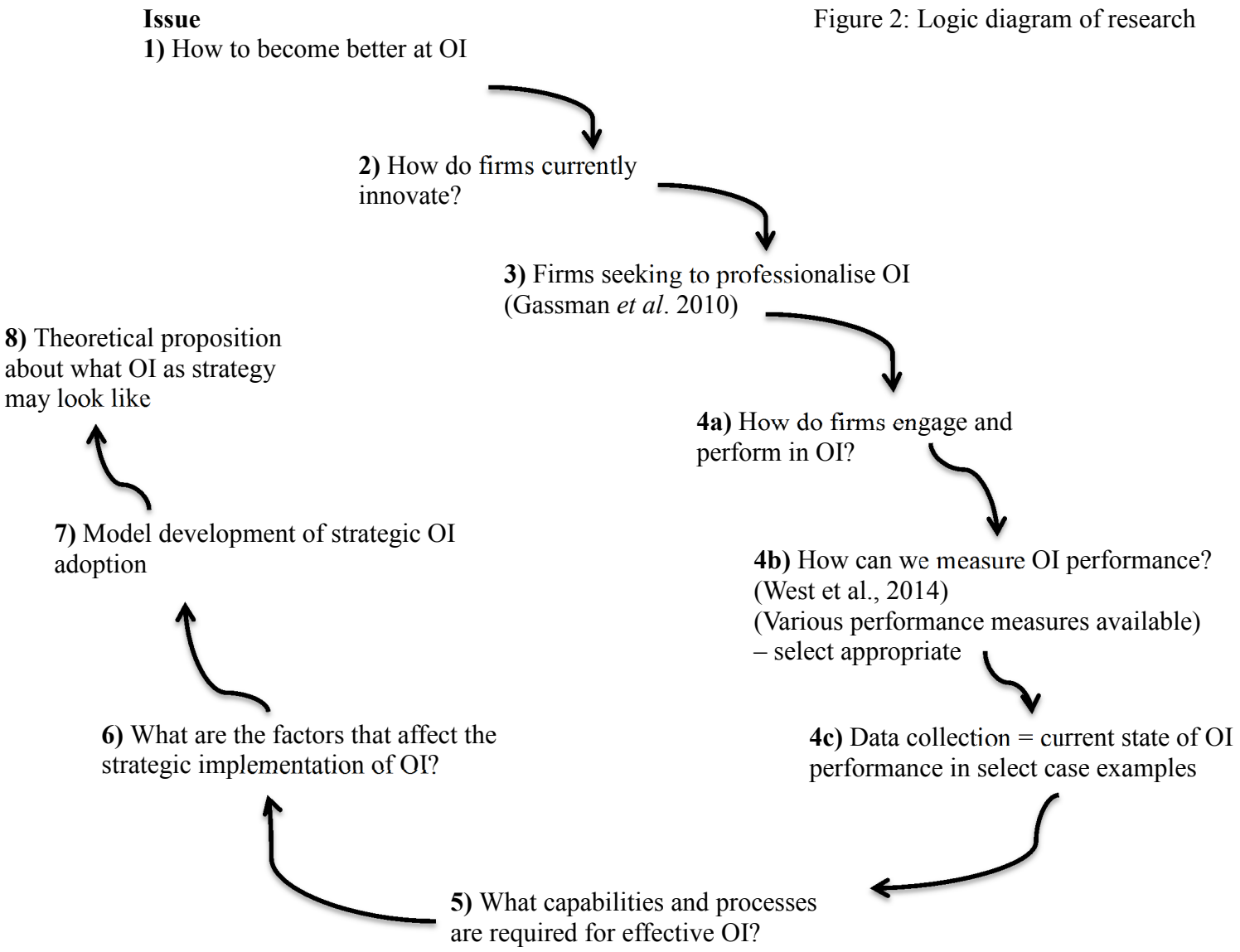
This research aim was designed to uncover the ways in which firms go about open innovation. In terms of the strategic view point, this relates to firms showing evidence of: communication and dissemination of an OI vision, education of OI, cultural and behavioural awareness, senior buy-in to OI, OI strategy development, an introduction of OI business units, OI champions, OI scouts, and the identification and definition of key OI processes. This study explores current levels of open innovation maturity with a view to providing suggestions as to how performance may be improved. Crucially, as Gassmann et al. (2010) identified, firms are seeking to professionalise their open innovation activities, and one of the issues of this research is identifying the factors that affect the strategic implementation of open innovation. The overall research aim was influenced by *the lack of awareness about how firms actually engage in open innovation* (Enkel et al., 2009; Buganza et al., 2011), and the limited means in which to assess open innovation performance (Enkel et al., 2011).

At the moment, there is awareness about the organisational modes of open innovation (Bianchi et al., 2011), but the lack of understanding rests with the uncertainty around the processes employed within each activity. This is reflected in the comments made by Wilden et al. (2013); Fredberg et al. (2008); Minshall et al. (2010), who share a similar opinion about the limited empirical research investigating the organisational capabilities and processes associated with a firms internal structure and the external environment. Moreover, because of this, there is also *a lack of knowledge regarding open innovation process maturity*. Not only that, but Hutter (2014) recognised the need for understanding the capabilities and practices needed for open innovation and directed attention towards organisational processes, structures, and culture. Specifically, this study is concerned with identifying the key competences an organisation needs in order to be proficient in inbound open innovation. In a recent paper by Bititci et al. (2012, 315), they discuss how the literature on performance management has evolved over time, and ask the question: 'do we need to measure and manage innovation and knowledge in an open environment?' As a response, this research would argue that because knowledge is regarded as one of a firm's greatest assets (Teece, 1998; Rosenzweig and Mazursky, 2014), developing mechanisms to help improve the innovation process is absolutely necessary regardless of the environmental factors. Also, as previously mentioned, Bititci et al. (2012) noted that firms are increasingly moving towards a much more collaborative and involved state. Therefore, management need mechanisms that allow them to assess the performance of innovation in such a context (West et al., 2014).

In order to be aware of the important factors to consider when designing a model of strategic open innovation adoption, one must first understand how firms go about open innovation. Measuring the current state of open innovation activity within a

firm can help accomplish this. Once there is awareness of current maturity levels, it will be possible to gain an understanding for the most relevant factors related to the design of a strategic model. The diagram below helps provide an illustration of the overall plan for this study.

Figure 2: Logic diagram of research



1.2.1 Research objectives

Like Bititci et al. (2011), this research considers activities in an organisation as a process (Deming, 2000; Slack et al., 2006). As Ray et al. (2004) suggested, it is only until a firm's resources and capabilities are translated into processes that a firm's true potential can be realised. In order to achieve this, several initial research objectives were devised:

Objective 1: Gain a better understanding for what open innovation is

This research objective is motivated by the fact that the idea of open innovation is still relatively new. Therefore, there is a need for better understanding of the concept so that contributions on the subject are well informed. Initially, this understanding will be achieved from reading literature and theory on open innovation, and later supplemented by combining evidence from practice.

Objective 2: Explore how firms engage in open innovation

The second research objective takes into consideration a wide range of literature on open innovation, and in turn, focuses on the most pertinent issues relating to the inflow of knowledge into the firm. By doing so, this provides a mechanism in which to further investigate the processes employed for these specific activities.

Objective 3: Investigate the processes related to open innovation and how outputs are measured

The final research objective is an opportunity to evaluate the effectiveness of current open innovation practices and to consider key factors that would impact on the strategic implementation of open innovation.

1.2.2 Scope of the research

Setting the boundaries of research is necessary, as this should help prevent the possibility of deviating away from the initially identified issues. Sometimes, describing what the research is not can help paint a better picture of what it is. Therefore, this section will start by describing what the research will not do, before further outlining what it will do. The following statements are based on consultation with a map that was created during the literature review stage, which attempted to link associated streams of literature on open innovation together. This process provided an ability to become familiar with key concepts surrounding the subject. Crucially, this map gave an indication towards the scope of research on OI, creating the possibility to narrow focus towards specific areas.

Although open innovation encompasses both inbound and outbound activities, this research will only focus on inbound activities. Therefore, there is only an interest in the movement of knowledge and technology into the firm. Attention will not be

given towards outbound open innovation. This is primarily due to the requirement for focus, and also incorporating the aspect of outbound open innovation into the study may reduce the ability to perform all the data collection required, thus impacting on the quality of research. Given that inbound open innovation is the most popular method of open innovation utilised by firms (Chesbrough and Crowther, 2006; Bianchi et al., 2010; Grönlund et al., 2010), it was realised that this area of investigation would be potentially more attractive for case study companies to learn about and engage with (West et al., 2014). In addition, although there would be interest in exploring outbound open innovation for the purposes of theory development as this is not an extensively explored area within the literature (Enkel et al., 2009), it was recognised that exploring this line of enquiry may be slightly risky for a PhD as this dimension of open innovation is less commonly used by firms. Also, it is recognised that intellectual property is a key topic within open innovation literature. Yet, similarly, intellectual property will not be given priority focus in this study. As a result of its complex nature, it is felt that this subject alone requires sole focus in research, and only attributing a portion of investigation to this area does not provide enough weight to its importance.

Instead, the main issue of this thesis is finding out how firms can become better at open innovation and establishing the state of their current open innovation activities. Such findings will provide avenues for further research so that the literature can be developed. Before continuing, it is necessary to highlight that one recent publication has addressed open innovation in the context of dynamic capabilities (Ridder, 2011), and another has developed an Open Innovation Maturity Framework (Enkel et al., 2011). Having said that, the framework by Enkel *et al*. (2011) has not been used as an analytical tool within this study as it does not include a strategy component. Both articles are valuable to this thesis in that they individually highlight areas of literature that are important. However, the unique contribution to knowledge that this thesis presents is combining dynamic capabilities and open innovation to a model of innovation maturity. This type of research is supported by Lichtenthaler (2011a) who suggested that future works can avoid communication barriers to theory development by building and combining open innovation with earlier theoretical concepts e.g. dynamic capabilities (Teece et al., 1997). Such a move will help advance theory on open innovation by identifying how firms manage OI activity. There is a dearth in research on the area of open innovation and dynamic capabilities, as well as open innovation maturity. Overall, the work of Ridder (2011) and Enkel et al. (2011) show interest in these areas and highlight them as interesting areas for further research.

1.2.3 Industrial context of research

The initial literature review and background theory on open innovation has made it possible to identify industrial contexts in which open innovation research is yet to explore (see section 2.2.5). Therefore, in an effort to contribute valuable knowledge, this thesis has sought to achieve a balance between pursuing research within sectors of economic importance to Scotland and the United Kingdom, as well as sectors that are yet to be studied in open innovation literature, thus reflecting a context specific approach (Huxham and Beech, 2003). Not only has the energy sector been largely

omitted from OI research, but the oil and gas industry represents an extremely important part of Scotland's industrial make up and provides a unique opportunity to investigate OI in context whereby the external environment that is generally very slow to change or accept new technology (slow clock-speed). In 2012, the Technology Strategy Board (now Innovate UK) published their High Value Manufacturing Strategy, which detailed several priority industries, split between growth opportunity and R&D intensity. Key areas identified associated with the oil and gas industry includes: marine, aerospace, electronics, optical products, chemicals, machinery and equipment (Technology Strategy Board, 2012). This section will briefly provide an insight into the oil and gas industry in order to set the industrial scene of this thesis.

The upstream sector of the oil and gas industry is used to describe the activity of developing and operating fields to extract crude oil and natural gas (Department of Energy & Climate Change, 2012). Alternatively, this section of the industry is also referred to as the exploration and production (E&P) sector. Major firms operating in this area include: Chevron, BP, Shell, Statoil, Total, BG Group, Exxon Mobil, Petrobras, Apache and ConocoPhillips (to name a few). For this operation, there are many different types of rigs that are used e.g. fixed jacket platforms, semi-sub drilling rigs, drillships, and drill barges. However, the three most popular rig types according to percentage utilisation are the semi-submersibles (91.6%), jackups (84.7%), and drillships (83.5%) (Rigzone, 2013b).

The North Sea represents the largest subsea market in the world, with over 1,700 wells (FMC Technologies, 2012). Yet, the UK Continental Shelf (North Sea) is by no means the most productive, nor is it the only location that has oil reserves. Recent trends show that oil and gas firms are benefitting from deepwater regions in West Africa, the Gulf of Mexico, and Brazil (Chevron, 2013). Field services companies such as Halliburton and Baker Hughes specialise in the manufacture of drilling equipment. These companies will sell that drilling equipment to the operators (BP, Chevron, Statoil, and Shell). The operators do not drill for oil and gas; they utilise technologies (seismic surveys and 3D visualisation) to identify potential locations that contain oil and gas reserves, and build the rigs (BP, 2013). The drilling process is then contracted out to another firm, such as Archer Drilling or Transocean Drilling. To enable the production of a well, E&P firms require additional products from another set of suppliers. Such companies manufacture machinery and equipment that specialise in subsea engineering. Companies in direct competition with one another include: FMC Technologies, Cameron, GE Vetco Gray, Aker Solutions, and Schlumberger (Rigzone, 2013a).

As industry experts acknowledge the fact that most of the easy oil and gas in the North Sea has already been recovered (Chazan, 2013), the technological challenges confronting oil and gas firms are substantial. Limitations in existing technologies means that up to two thirds of oil can remain in a reservoir (Glasgow Caledonian University, 2011). The reality is that the North Sea is a mature field, albeit with approximately 20 years production left. Extraction is going to be more costly than before because of the technical challenges associated with these operations.

Moreover, the list below provides an example of some of the technical tasks oil and gas firms have to overcome throughout the industry:

- Improve production from mature wells (National Subsea Research Institute, 2011; Oil & Gas UK, 2013; Wood, 2014)
- Harsh environments (FMC Technologies, 2013)
    - Deep water (Beckman, 2013)
    - Ultra deep water (National Subsea Research Institute, 2011; Boman, 2012)
    - High pressure
    - Arctic (Kerr, 2012)
- Monitoring solutions
    - Real time (McStay et al., 2009)
    - Flow
    - Condition
    - Leak detection (Moodie, 2013)
- Unconventional gas

Technology trends in the oil and gas industry indicate that there is a movement towards high-speed wireless communication, hydraulic to electric power, condition performance monitoring, and improved flow and separation technology (Kerr, 2012). Undoubtedly, innovation will be the driver to accomplish the challenges that exist in the industry. Scotland is home to much of the World's greatest expertise in oil and gas (Scottish Enterprise, 2012b), and the industry will continue to be a priority area in the eyes of the Government (Scottish Enterprise, 2013). However, meeting and tackling these technology issues will require collaboration, knowledge transfer, and an open approach to innovation (Scottish Enterprise, 2012b; Wood, 2014).

1.3 Research approach

An initial period of approximately twelve months was spent immersed in the literature in order to become familiar with the state of the art as well as finding a suitable research gap. To begin this journey, the starting point was reading Chesbrough (2003) and Chesbrough (2006). During the course of reading these texts, summary sheets were prepared highlighting the key points within the chapters. In addition to this step, potentially interesting and relevant texts that were referenced in these books were highlighted to further explore at a later date. Such texts included Cohen and Levinthal (1990), Laursen and Salter (2004), Leonard-Barton (1992), March (1991), Pisano (1990), Rothwell (1994), Teece (1986), and Teece et al., (1997). The literature review process also involved lengthy and extensive keyword searches on academic databases. The databases that proved to be most helpful in this search included: Science Direct, Wiley, Emerald, and ISI Web of Knowledge. The first search was 'open innovation', and this produced a significant number of hits, but without a great deal of focus. As an example, Huizingh (2011) noted that a single search for the term 'open innovation' on Google Scholar provided over 2 million results. Other keyword searches entered into the databases included the following (with and without the term 'open innovation' additionally added): inbound,

outbound, absorptive capacity, open source software, networks, external search, internal search, R&D collaboration, radical innovation, incremental innovation, technology transfer, and intellectual property to name a few. Evidently, this produced a vast array of interrelated literature, all of which was related to open innovation, but was very disjointed and not easily manageable. Therefore, this necessitated the desire for improved structure, and resulted in developing a visual tool to help with identifying the relationships between the topics. In addition to the process described above, thematic journal review tables were created, documenting the context, name of authors and title of paper, the paper's aim and focus, methodological approach, and any gaps or future research areas noted. From analysing both the mind map and journal review tables, it was then necessary to select an area of focus for further inquiry. It became clear that many of the papers published were based on case studies describing how companies were 'doing' open innovation. However, there was a gap to try and find out how this initiative was managed, which ultimately led on to looking at the processes associated with open innovation (Gassmann et al., 2010). Once the focus was decided upon, the decision was made to approach firms to participate in research that would investigate innovation processes. This initial literature review period resulted in reading in the region of 150 texts. Although, over the three year research period this figure rose as it was necessary to keep up-to-date with the latest publications coming from relevant journals such as R&D Management, Technovation, Research Policy, and Strategic Management Journal.

To supplement the desk research exercise, a workshop entitled *The Open Innovation Imperative* was attended at the University of Edinburgh Business School on 12th January 2012. Attending this workshop was particularly beneficial as this was the first opportunity to listen to experienced academics talk about open innovation.

1.3.1 Contribution to knowledge

This thesis is important to the development of open innovation literature for several reasons. At the moment, interest in open innovation is growing throughout academia and industry (Huizingh, 2011; Cheng and Huizingh, 2014), and the literature recognises collaboration as a vital component to successful innovation (Mendibil et al. 2013; Rothwell, 1992). Therefore, more investigation is required to understand how firms are managing the open innovation process. Moreover, in a special issue of *R&D Management*, Gassmann et al. (2010, 216) assert that 'industry is trying to professionalize the internal process to manage open innovation more effectively and efficiently'. They also mention that 'while the possibilities of opening the innovation process are growing, metrics systems are not yet adopted to monitor and measure the value of activities (Gassmann et al. 2010, 216). In turn, this research has chosen to focus on the premise that firms are interested in becoming better at open innovation, and therefore the aim is to understand how this can be achieved.

The initial starting point of this research was concentrating on the comment made by Chesbrough (2003), whereby he suggested that we could be witnessing a paradigm shift from closed to open innovation in terms of the way in which firms commercialise knowledge. At that point in time, it was relatively unknown how

firms manage their open innovation activities. However, what the data from this research shows is that while firms do indeed utilise external sources of knowledge to advance their technological capability, it is rarely an objective move towards adopting open innovation as an operating model. What this means is that companies are yet to undergo internal transformation in their business to reflect open innovation. Therefore, while there is great popularity in the concept of open innovation among academia and industry, this attractiveness may not necessarily be translated into change at the corporate level i.e. in strategy (Bader and Enkel, 2014). Put differently, despite there being a confirmed link between strategy and innovation (Gianiodis et al., 2010), further work is required to explore the impact strategy has on a firm's openness decisions. In fact, using open innovation as an operating model (Kutvonen, 2011) to leverage value may not be as popular as initially portrayed in the literature. This is fundamentally centred on the evidence that firms are yet to manage open innovation activity. Crucially, a major contribution of this thesis is that companies have shown to be successful without adopting open innovation as their operating model. Therefore, it is not open innovation that is key to success, but the level of maturity towards innovation processes. Having said that, some companies were found to do open innovation, but only at a low intermediate level of maturity. Therefore, while one may not expect to find evidence of open innovation in a slow clock-speed industry, this research actually found some evidence of it in a sample of companies.

Following on from the main issue of this study about how to become better at open innovation, this thesis presents several capabilities that are needed for its success, thus providing valuable theoretical knowledge to the field of study. To disseminate output of this research, there was active participation in a number of academic conferences. In June 2013, the proposal for this PhD study was presented at the 20th EurOMA Conference: Operations Management at the Heart of the Recovery. Additionally, throughout June 2014, preliminary research findings were presented at the R&D Management Conference in Stuttgart, and also the 21st EurOMA Conference: Operations Management in an Innovation Economy. These papers can be viewed under the appended papers section of this thesis.

1.3.2 Contribution to methodology

Research on open business models is in an early stage of development (Frankenberger et al., 2014), and Spieth et al. (2014) encourages further research along the business model innovation theme. Additional empirical studies are required to explore the extent of open innovation in all industry contexts (Chesbrough and Crowther, 2006). As a result, there is requirement to fill this research gap. This research builds on the previous work of Ridder (2011), who also recognised the compatibility between dynamic capabilities (Teece, 2007) and open innovation. Limited research adopts the sensing, seizing, and transforming pillars of dynamic capabilities to investigate open innovation activity. Consequently, this thesis uses the dynamic capabilities framework to structure a deductive-based open innovation maturity model.

The content of the maturity model is derived from theory on open innovation, strategy, business processes, and performance improvement. Further, as the model incorporates the maturity scale used by Bititci et al. (2011) from their Manage Processes study, it is possible to gain a maturity assessment for a number of key open innovation themes, including: innovation environment, business processes, individual roles, and performance measurement. Through a series of innovation workshops and interviews with industry professionals, it was possible to obtain an understanding for the strategic adoption of open innovation in industry. Not only does the data collection procedure employed offer a novel contribution to methodology, but the development and testing of the open innovation maturity model demonstrates a valid contribution to knowledge. Crucially, taking the comments made by Gassmann et al. (2010) about metrics systems and monitoring activities, this research provides a means to measure current open innovation maturity levels (West et al., 2014).

1.3.3 Contribution to practice

As noted by Scottish Enterprise (2012a), meeting and tackling the immediate and future challenges facing the oil and gas industry will require an open approach to innovation through collaboration and knowledge transfer. This research is noted for bringing managerial attention towards the management of innovation. Particularly for the individuals taking part in the innovation workshops, this in-depth session revealed a number of internal issues that may have encouraged them to reflect and improve their approach to innovation.

Additionally, the development of a theoretically grounded maturity model enables firms (who are interested in operating by the open innovation model) to assess how far they have incorporated OI into their operations. Furthermore, through the development of a valid and practical model regarding strategic open innovation implementation, firms will become more aware of how to organise themselves internally to become better at open innovation.

1.4 Thesis structure

Figure 3 highlights the overall structure of this thesis. This illustration provides a visual of the relationships between the documented chapters, and also a description of the key issues to each section.

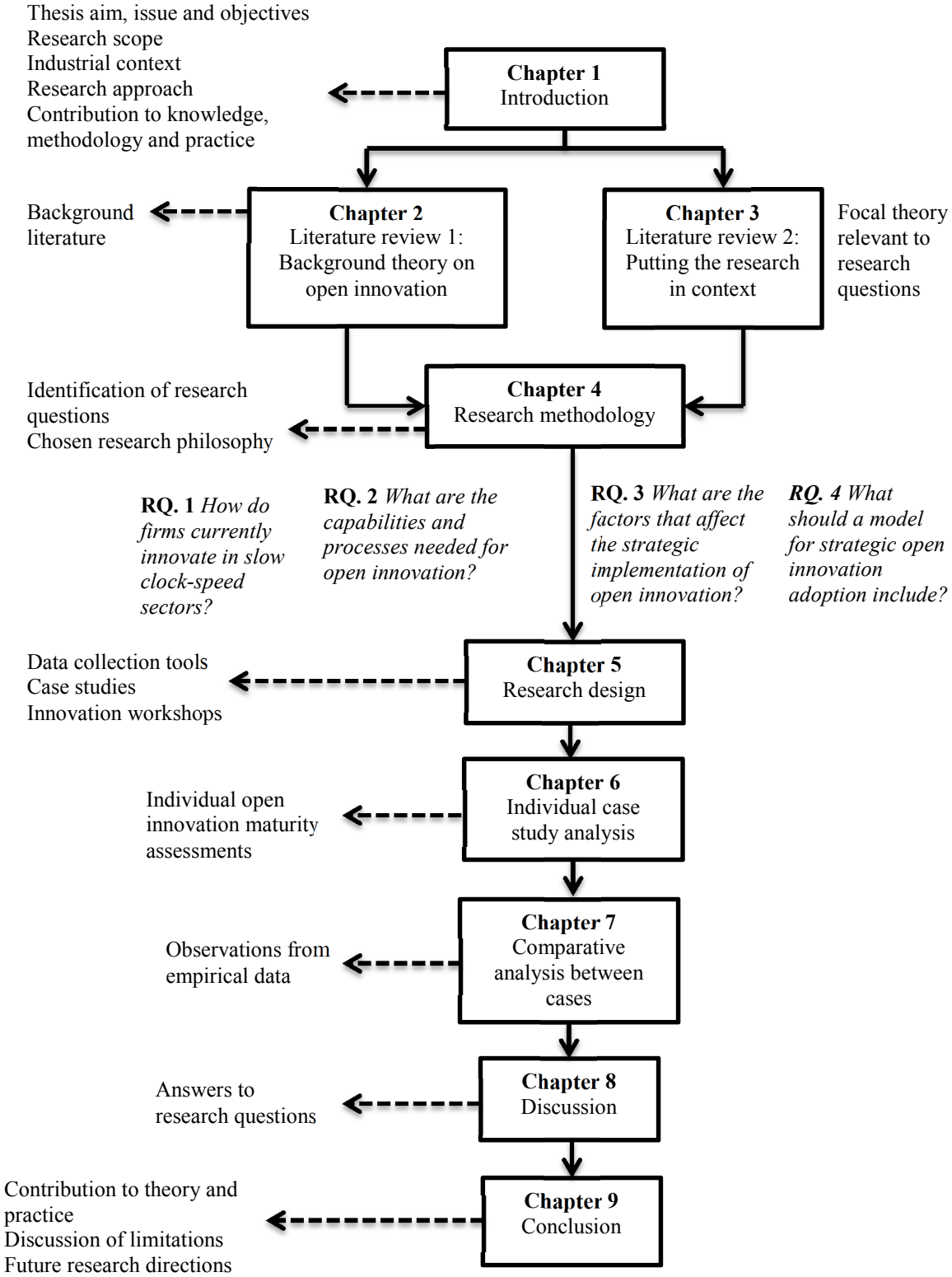


Figure 3: Structure of thesis

Chapter 1 discusses the motivating factors for this study, highlighting the research issue, objectives and scope of the investigation. Also, a brief summary of the approach to research is included, highlighting the research journey taken. Furthermore, in order to provide industrial context to the study, background information on the oil and gas industry is presented before commenting on the contributions to theory, methodology, and practice.

Chapter 2 reviews the founding thoughts on open innovation (Chesbrough, 2003), discussing the difference between closed and open innovation. Additionally, current trends and research gaps in open innovation research is identified. This section of the thesis also introduces the research questions for the study, before providing information relating to the industrial context of the research. Chapter 2 offers the necessary foundation knowledge on open innovation so that the reader is aware how the focal theory in chapter 3 relates to the aim of the research.

Chapter 3 is primarily associated with building on the knowledge from chapter 2 to help address the chosen research questions. This chapter is split into two distinctive parts. Chapter 3 part I focuses on strategy literature, specifically looking at competitive advantage and dynamic capabilities. Part II then explores literature on business processes (Hammer, 1990; Hickman, 1993) and various maturity models.

Chapter 4 starts with an overview of the methodological terminology before reiterating the research aim and the research questions. Questions are related to understanding of how firms can become better at open innovation. This chapter however, is predominately centred upon philosophical worldviews, with the ultimate aim of being guided by a particular research philosophy. The pragmatist worldview provides a suitable means in which to answer the research questions (Creswell, 2009; Creswell and Plano Clark, 2011).

Chapter 5 marks the introduction of the research design for this PhD. The chapter documents the chosen approach for data collection. For reliability purposes, a case study protocol was created, of which details the necessary steps to be performed during data collection. In terms of practicalities, this research utilises a case selection criteria framework to identify suitable case studies. Moreover, innovation workshops and interviews form the main data collection procedures for gathering data. Also, chapter 5 introduces the case study firms through SIC code classification and activity description as registered on the FAME database. Finally, options for data analysis are considered.

Chapter 6 individually analyses open innovation maturity for three firms within this study. The chapter provides a unique insight into maturity levels for the companies that participated in an open innovation maturity assessment using the OI maturity model.

Chapter 7 comparatively analyses the cases and presents a number of key observations related to innovation environments, business processes, individual roles for innovation, and performance measurement activities.

Chapter 8 is predominately focused on providing answers to the research questions set in the methodology chapter. To begin, the discussion starts by describing how firms innovate. Next, capabilities and processes necessary for open innovation are identified. Subsequently, factors that could affect the strategic implementation of open innovation are addressed. Finally, this chapter concludes by providing a tentative design for a model of strategic open innovation adoption.

Chapter 9 draws together the key contributions of the thesis. Attention is given to theoretical and managerial implications as well as limitations and directions for future research. This thesis concludes by reflecting on the PhD research experience.

Chapter 2. Literature review 1: Background theory on open innovation

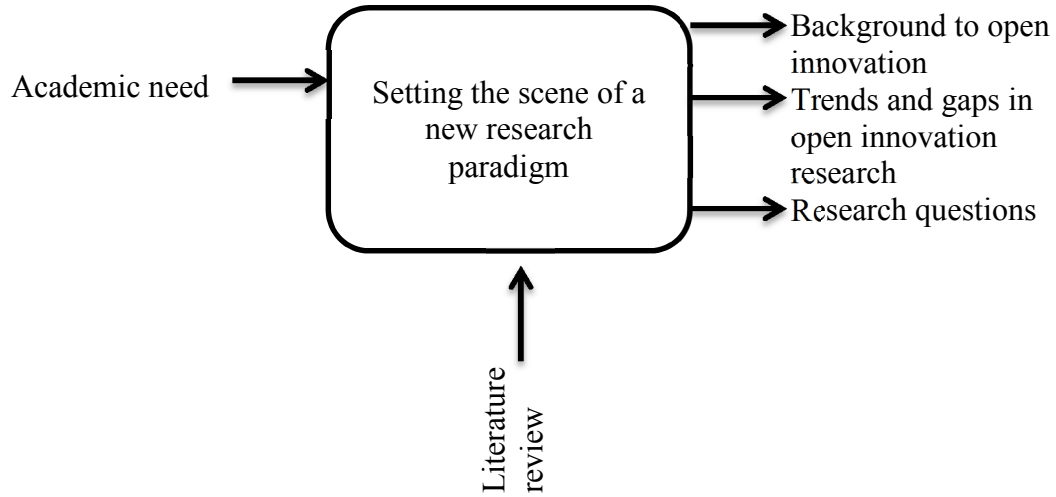


Figure 4: Chapter 2 input - output diagram

2.1 Introduction

The purpose of this chapter is to first provide an introduction to the literature on innovation. This will then be broadened out to give an overview of the open innovation paradigm - its various dimensions and how the topic has developed since its discovery in the computing industry and introduction to academia in 2003. Moreover, this chapter is aimed to give an interpretation of an evolutionary understanding of open innovation. The chapter starts by discussing the transformation of innovation activities, and concludes by presenting the research questions.

2.1.1 Evolution of innovation

'Innovation' was defined by Schumpeter (1934) as the commercialisation of combinations of the following:

- New materials and components,
- The introduction of new processes,
- The opening of new markets,
- The introduction of new organisational forms

For this research, the introduction of new processes and new organisational forms is particularly relevant. In order to understand how the innovation literature has reached a point whereby the idea of a paradigm shift is being discussed (Chesbrough 2003), it is first important to map the direction of prior works.

In a much recognised and widely respected article, Rothwell (1992) captures the various ways in which companies have commercialised technology over the years. His 1992 paper in particular chooses to focus upon what he calls 'the fifth generation innovation process'. The first generation innovation process is categorised by a 'technology push' model, a sequential and linear process whereby the market is the recipient of outputs from R&D. The second generation innovation process is reflective of a need pull situation whereby the market becomes the source of ideas for research and development activity. Following this, the coupling model (third generation) representative of the late 1970s and early 1980s still shows a sequential process, but with feedback loops, resulting in a combination of both push and pull forces and generally a greater balance between R&D and marketing. The fourth generation innovation process represents an integrated model with input from suppliers, customers, and integrated teams. This model attempts to highlight the integration between manufacturing and R&D. Finally, the fifth generation process of the 1990s is typified by a systems integration and networking model. At this stage in the innovation process, firms begin to use expert systems and simulation modelling during R&D, ultimately putting greater emphasis on quality. During this point, knowledge begins to enter the organisation from a variety of sources and the firm is engaged in a number of initiatives e.g. joint ventures, collaborative research, and collaborative marketing.

Final remarks made by Rothwell (1992) indicated that both internal and external resources are increasingly being used in the innovation process. This point is similarly made in Story et al. (2009), who projected that there is a greater trend towards non-linear and less rational approaches for innovation that use alliances, partnerships, joint ventures (JV), and networks. Nowadays, there are simply increased challenges for firms that innovate in isolation (Teece, 1986; Hamel and Prahalad, 1994; Shan et al., 1994; Tether, 2002) due to shorter product lifecycles (di Benedetto, 2010), higher R&D costs, and greater consumer sophistication. This net result means that successful innovation is increasingly dependent upon on the successful integration of external ideas during the innovation process (Arora and Gambardella, 1990; Cassiman and Veugelers, 2002; Helfat and Quinn, 2006; Mina et al., 2013).

This involvement of external actors in the innovation process has consequently led to the remodelling of some traditional innovation processes. For example, the Stage-Gate process developed by Cooper (1990), was reconfigured by Grönlund et al. (2010) to incorporate open innovation options in the new product development (NPD) process. The Stage-Gate model conveys the NPD process as a series of decisions that need to be taken in order for a project to progress. This particular model represents the NPD process as a series of evaluation points, where a go/kill decision on the project is made (Cooper and Kleinschmidt, 1991; Hart et al., 2003). In terms of the paper by Grönlund et al. (2010), they specifically studied GE Vetco Gray – a firm specialised in upstream drilling and process technology for the subsea oil and gas industry. Feedback from interviewed Vetco Gray employees indicated that the firm could gain quite substantially from extending the search for technology and knowledge outside the confines of the oil and gas industry. Although, no systems are currently in place for performing this type of search (Grönlund et al., 2010).

Therefore, giving support for research into finding ways to improve the inbound innovation process.

The statements above indicate that companies are more engaged with bringing knowledge into their company to try and improve their competitive position, rather than seeking to offload knowledge. The literature recognises a series of success factors that lend itself towards the foundations of open innovation, including establishing 'effective linkages with external sources of scientific and technological know-how; a willingness to take on external ideas…involving all departments in the project from the earliest stages…emphasis on satisfying user-needs; efficient customer linkages where possible, involving potential users in the development process…effective product champions… and open minded managers' (Rothwell, 1992, 223, 224). In addition, Cooper (1984) highlighted some strategies that can lead to high innovation performance i.e. having a strong orientation towards R&D coupled with a proactive attitude towards acquiring new technologies. This should also be directed towards having strong user linkages and identifying user needs by involving them in the innovation process, in combination with searching for new product ideas. Therefore, by acknowledging that these sentiments were written before open innovation was coined, it is necessary to try and understand how open innovation is different.

2.1.2 Addressing the topic of open innovation

Before a review of the focal literature is presented, it is necessary to explain what the topic of open innovation is and provide a definition. Since Chesbrough (2003) suggests that the research and industrial community is witnessing a paradigm shift from 'closed innovation' to 'open innovation', comparing these two dichotomies is perhaps the most logical way to explain what open innovation is. Although there may be some criticism towards the authenticity and reliability of 'closed innovation' (Trott and Hartmann, 2009), presenting information in a manner similar to Chesbrough (2003) allows for consistency. This method subsequently allows an opportunity to appraise the topic.

Professional industry exposure to the computer industry has enabled Chesbrough to become aware of companies choosing different pathways for commercialising industrial knowledge. Consequently, this has prompted him to signal a paradigm shift. In order for Chesbrough to articulate this change in commercialisation activity and introduce the concept of open innovation, he was obliged to develop the closed innovation paradigm, as a prerequisite for proposing a shift in paradigm.

2.1.3 Closed innovation

The closed paradigm assumes that 'companies must generate their own ideas and then develop them, build them, market them, distribute them, service them, finance them, and support them on their own' (Chesbrough, 2003, xx). This statement subsequently implies that a single firm would be in control of all features of the

supply chain, from research and discovery, through to servicing and after care. The closed model can be thought of in terms of the traditional, vertically integrated R&D model where internal R&D leads to the commercialisation and distribution of products by the firm (Chandler, 1990; Schroll and Mild, 2011). The figure below provides an illustration of the closed innovation paradigm; similarities can be drawn from the Stage-Gate process and the product development pipeline (Cooper, 2000). In the closed innovation process, ideas and research projects occur internally. This internally focussed aspect is key to everything that encompasses the closed paradigm. The thick line in the figure should be thought of as an impenetrable wall (i.e. only internally generated research projects can escape into the market through the company's own business model). Within the research stage, there may be a large number of projects, however, decision makers within the firm will assess what research projects are worthy of further funding; successful ones will progress into the development phase. Projects that do not make it into the initial development phase may be brought back at a later date. However, it is also common that the research phase is far as some projects will ever go. Once a project has successfully exited the development phase, the product/service is taken to market.

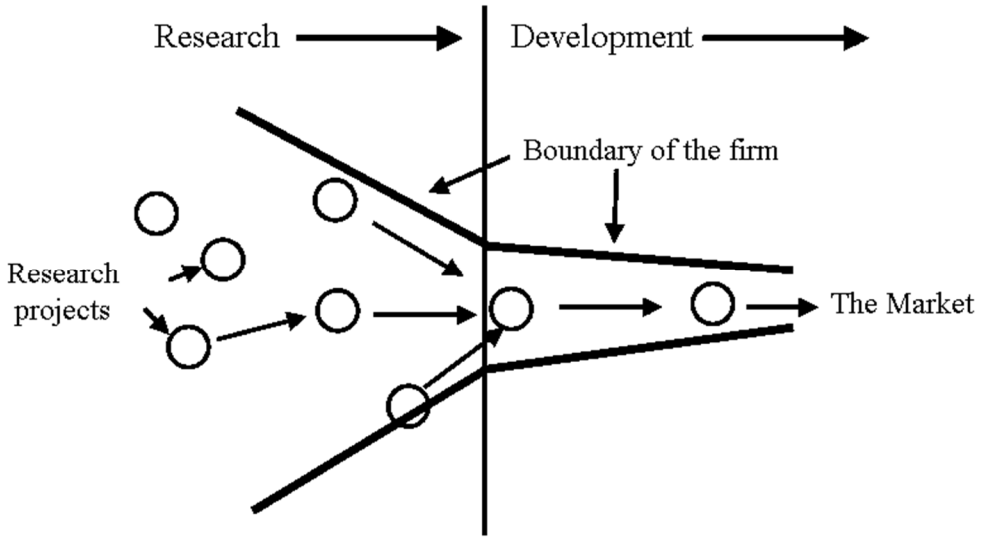


Figure 5: Closed innovation

(Chesbrough 2003)

Table 1 provides a summary of the fundamental principles of closed innovation (Chesbrough, 2003).

Principles of closed innovation
The smart people in our field work for us
To profit from R&D, we must discover it, develop it, and ship it ourselves
If we discover it ourselves, we will get it to market first
The company that gets an innovation to market first will win
If we create the most and best ideas in the industry, we will win
We should control our IP, so that our competitors don't profit from our ideas

Table 1: Closed innovation principles

Keeping those identified principles in mind, Chesbrough (2003) proposed several socio-economic factors (Duarte and Sarkar, 2011; Schroll and Mild, 2011) which challenge the very existence of closed innovation in today's business environment:

- Increased mobility of experienced and skilled workers
- People who obtained university and post-university degrees are moving into companies of different sizes
- Growing venture capital (VC) investment in start-up firms
- Reduced time to market for products and services
- Shorter product lifecycles

2.1.4 Procter & Gamble highlighting impracticalities of closed innovation

The case of Procter and Gamble (P&G) highlights the difficulties for such a large organisation to operate under a closed innovation model. Huston and Sakkab (2006) mentioned that internal innovation worked well when P&G were a $25 billion company. However, now that they are almost a $70 billion company, obtaining 4% to 6% yearly growth would be the equivalent of building a $4 billion business each year (Huston and Sakkab, 2006). Therefore, in order to alleviate the enormity of this task, P&G's new strategy is to leverage external knowledge in the hope that this will lead to continued growth. Former CEO, Alan Lafley made it the company's goal to acquire 50% of innovations from external sources (Huston and Sakkab, 2006). To many, this would seem radical. P&G managed to reduce spending on R&D and introduce more products to market than ever before. Therefore, the decision to move from an internally focused company to one that relies on the innovations of others has been a positive move for the firm.

2.1.5 Authenticity of closed innovation

In terms of the principles of closed innovation, Trott and Hartmann (2009) are strongly opposed to the idea of closed innovation. They propose that Chesbrough's (2003) closed model misrepresents the true position of innovation management, and as a result, Chesbrough is able to abandon it in favour of open innovation (Trott and Hartmann 2009). To provide context, one of Chesbrough's (2003) principles of closed innovation is that 'the company that gets an innovation to market first will win'. However, by analysing trends throughout the 20th Century based on pioneer vs imitator/late entrants, it is possible to show that Chesbrough's (2003) argument does not hold. Leica pioneered the 35mm camera, but it was Canon and Nikon who ended up dominating. Furthermore, the first CAT scanner was commercialised by EMI, yet they had no experience in the medical industry. Soon, Pfizer, GE, and Johnson and Johnson were able to copy it and deploy it much more successfully. More recently, Google have become the leader of Internet search engines, despite not being first to market (Trott and Hartmann 2009). Therefore, for Chesbrough (2003, xxvi) to base an argument for closed innovation as 'the company that gets an innovation to market first will win', cannot stand. There are instances when being the first mover brings advantages, but the examples above indicate that this is not always necessary to be successful (Lieberman and Montgomery, 1998; Markides and Geroski, 2005; Markides and Sosa, 2013).

Also, another of Chesbrough's (2003) closed innovation principles is that 'all the smart people work for us'. Trott and Hartmann (2009) propose that building any argument on this premise is simply misguided. This discussion is not meant to contest the authenticity of open innovation; it is questioning whether or not companies ever held a true position of closed innovation, whereby there was absolutely no influence from the outside on internal operations. Rothwell (1992) provided evidence to support the view of open innovation, in the fact that companies have benefitted from collaboration and external sources of knowledge for many years. In addition, as far back as 1969, the opening statement in Allen and Cohen (1969, 12) stated that, 'no research and development laboratory can be completely self-sustaining. To keep abreast of scientific and technological developments, every laboratory must necessarily import information from outside.' Furthermore, Robertson et al. (2012) supposed that open innovation has perhaps historically been the rule rather than the exception for firms operating process technology. This point is illustrated by Landes (2003) who indicated that many specialised manufacturers in the UK throughout the 19th century who developed textile machinery, steam engines, and other machining tools actively used external sources of information to help them develop process technologies. Collectively, this adds to the questionable nature of closed innovation – did it really ever exist? Hence, did Chesbrough (2003) need to propose a paradigmatic shift? Additionally, Minshall et al. (2010) bring attention to the fact that the model developed by Granstrand et al. (1992), long before open innovation was popularised, shows specific approaches for firms to become more open in their innovation process – from technology purchasing to technology scanning and selling.

In terms of trying to understand how Chesbrough (2003) developed the closed innovation funnel, it seems that the idea for open innovation was already set and he simply ended up re-creating a simplistic product development pipeline diagram to represent closed innovation. Given that the importance of engaging with externals has had an increased profile in recent years, it would also seem that, upon reflection, the traditional product development pipeline is becoming out-dated, as there is no inclusion of externals in the process. At this moment in time, the Open Stage-Gate model by Grönlund et al. (2010) seems more suitable in today's business environment as Robert Cooper's *original* Stage-Gate process does not involve any external search process or engagement with outsiders. However, Cooper (2008) recognised this move for gathering intelligence from multiple sources and updated his Stage-Gate process towards open innovation. Therefore, the Stage-Gate process of the 1980/90s may be deemed inadequate, while this updated version is more fitting. Although, one must not forget that Tidd et al. (2001) emphasised the importance of establishing links with externals in their Managing Innovation model also. The following section is structured in such a way that not only helps to position what open innovation is, but at the same time, seeks to convey the journey towards understanding open innovation.

2.2 What is open innovation?

Now that the concept of closed innovation has been discussed, it is necessary to proceed onto the topic of open innovation. To quote Chesbrough, he stated that,

> 'Open Innovation is a paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as the firms look to advance their technology. Open Innovation combines internal and external ideas into architectures and systems whose requirements are defined by a business model. The business model utilizes both external and internal ideas to create value, while defining internal mechanisms to claim some portion of that value. Open Innovation assumes that internal ideas can also be taken to market through external channels, outside the current business of the firm, to generate additional value' (Chesbrough, 2003, xxiv).

This statement can be interpreted from the figure below.

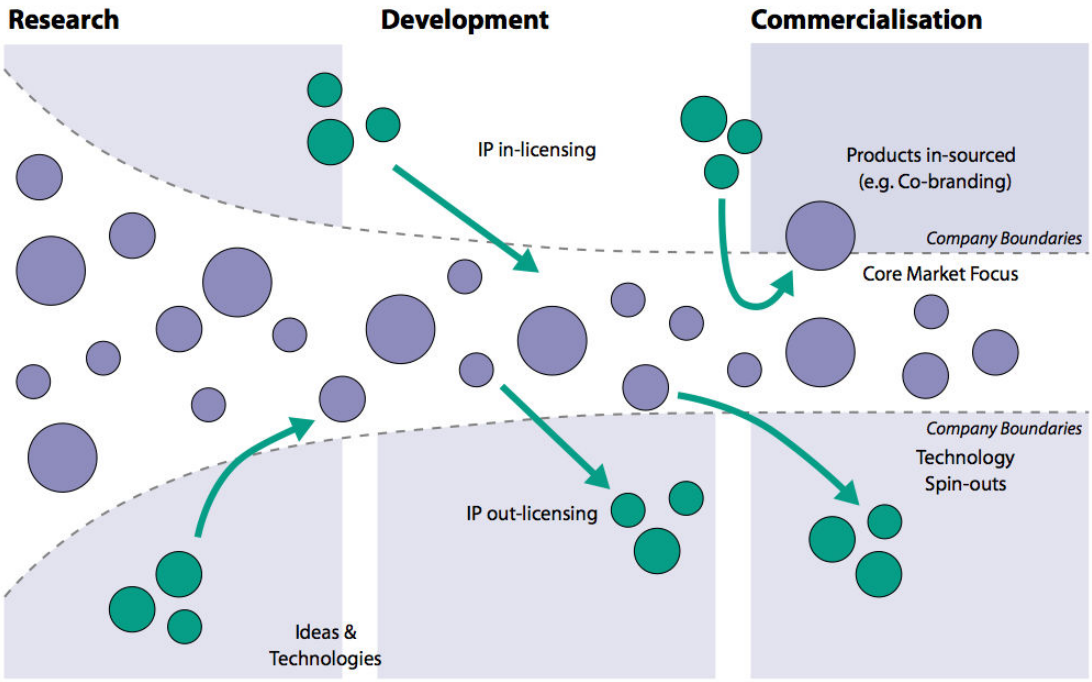


Figure 6: Open innovation

Source: Mortara (2010, 4)

Compared to the closed model, the open one represents a radical change in the way industrial R&D is managed. The first notable difference is the increase in activity within the model. One contrast between closed and open innovation is the location in which ideas and technology are generated. In closed innovation, only internal efforts would be used to take a research project from discovery to market. However, in open innovation practices, both internal and external knowledge sources are used. This notion is highlighted by the model's key feature, its permeable surface (as shown in the figure above). In essence, this means that technology and ideas can move into the firm from external sources, as well as out of the firm into external sources. Although, such transfer is only suitable if there is an appropriate business model to support the technology. The importance of the business model should not be underestimated, as this is the glue that holds the benefits of open innovation together. This can be highlighted by the case of Xerox PARC, whereby countless pieces of computer hardware and software were developed, but few were suitable for Xerox's business model (Chesbrough, 2003). Therefore, Xerox had to create spin-out companies in order for the technology to realise its commercial potential. Like closed innovation, Chesbrough (2003) provides a list of principles that encompass open innovation (table 2).

Principles of open innovation
Not all the smart people work for us. We need to work with smart people inside *and* outside our company
External R&D can create significant value; internal R&D is needed to claim some portion of that value
We don't have to originate the research to profit from it
Building a better business model is better than getting to market first
If we make the best use of internal and external ideas, we will win
We should profit from others' use of our IP, and we should buy others' IP whenever it advances our own business model

Table 2: Open innovation principles

(Chesbrough 2003, xxvi)

As mentioned earlier, some principles of open innovation were already taken on board by firms prior to Chesbrough (2003) coining the term, e.g. collaborative R&D and joint ventures (JVs). However, one principle that seems to be 'newer' and generally less embraced by firms is the idea of actively selling IP to external companies. What Chesbrough (2003) has managed to do successfully is bring an array of business activities under one umbrella term (Huizingh, 2011). If anything, the term open innovation has given companies the authority and the impetus to go and increase their search for external partners to collaborate with. Even although they may have used external sources before, the rise in interest of open innovation has probably been a catalyst and reassurance that external knowledge is beneficial to your business.

Upon reflection of the principles of open innovation, there needs to be more recognition that much of these ideas were already mentioned in the literature before the term 'open innovation' was published (Trott and Hartmann, 2009). Further research is required to understand what is new about open innovation compared to previous contributions.

2.2.1 Defining open innovation

In terms of a definition, Chesbrough (2006, 1) stated that, 'Open Innovation is the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively'. This is currently the most widely used definition within the literature. However,

others have expressed the need for more clarity (Lichtenthaler, 2011a). In fact, Groen and Linton (2010) started a debate in *Technovation* entitled: *Is open innovation a field of study or a communication barrier to theory development?* In this debate, the central role is to examine the novelty of the open innovation concept. Groen and Linton (2010) point to the potential resemblance between open innovation and the term supply chain management (Linton, 2012), a view also held by von Hippel (2010). This is due to the fact that supply chain management is concerned with gathering input from across the immediate supply chain i.e. customers, suppliers, and stakeholders (Groen and Linton (2010). However, von Krogh (2011) suggested that approaches at the extreme end of the openness spectrum may not be essential to a firm's supply chain due to the intrinsic nature of processes associated with open innovation. Therefore, it is necessary to stipulate where the boundaries of open innovation lie (Linstone, 2010).

In an attempt to address the issue of clarity, Lichtenthaler (2011b) seeks to offer a contribution. He defines open innovation from a firm perspective as 'systematically performing knowledge exploration, retention, and exploitation inside and outside an organization's boundaries throughout the innovation process' (Lichtenthaler, 2011b, 77). Lichtenthaler's (2011) definition correctly addresses the activity of knowledge exploration through a systematic process. However, based on Chiaroni et al (2010); Mortara and Minshall (2010) and their respective discussions related to organisational change, there is an obvious omission from Lichtenthaler's (2011) definition as there is no mention of open innovation requiring a change in mind-set (Gassmann et al., 2010). This is also true of Chesbrough's (2006) definition. However, the objective of his definition was perhaps to explicitly make aware the two-way flow of ideas moving into and out of the firm. Clearly, there is a lack of alternative definitions of open innovation (Bageac et al., 2014), and indeed a single agreed upon definition (di Benedetto, 2010). In an attempt to provide a more fitting account of open innovation to reflect recent contributions and developments in the literature, Chesbrough and Bogers (2014) have sought to offer a new definition. They define open innovation as 'a distributed innovation process based on purposively managed knowledge flows across organizational boundaries, using pecuniary and non-pecuniary mechanisms in line with the organization's business model.' From this new definition, it is possible to see that direction is being put towards open innovation as a managed process. A list of available open innovation definitions is presented in the table below.

'Open Innovation is the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively.'	Chesbrough (2006)
'Systematically performing knowledge exploration, retention, and exploitation inside and outside an organization's boundaries throughout the innovation process'	Lichtenthaler (2011b)
'Inbound open innovation designates an innovation strategy defined by frequent and systematic appeal to a variety of internal and external sources, for ideas, knowledge and technologies in the creation, by a firm, of its products and/or services.'	Bageac et al. (2014)
'A distributed innovation process based on purposively managed knowledge flows across organizational boundaries, using pecuniary and non-pecuniary mechanisms in line with the organization's business model.'	Chesbrough and Bogers (2014)

Table 3: Open innovation definitions

Initial understanding of open innovation through its definitions is that there is dual emphasis on internal and external knowledge. In addition, there is an importance placed on searching for knowledge inside and outside the organisation. At this stage, there seems to be subjective differences between this approach to innovation and others e.g. (Rothwell, 1992; Tidd et al., 2001). For example, all approaches note the significance that external knowledge can play on the success of a business. However, open innovation stresses a two-way movement of knowledge (in and out of the organisation). Perhaps open innovation is simply a better method of describing innovation for the 21st Century that encompasses a range of business activities. Next, the thesis provides detail on the dimensions of open innovation.

2.2.2 Dimensions of open innovation

There are three dimensions associated with open innovation, namely: inbound open innovation, outbound open innovation, and the coupled process. Each will be described in turn below. However, the predominant focus of this thesis is centred upon the inbound process, and this is justified at a later point.

2.2.3 Inbound open innovation

The beginning of this chapter highlighted that literature acknowledges the importance of importing external knowledge into the firm (Rothwell, 1992; Cassiman and Veugelers, 2002; Story et al., 2009; Mina et al., 2013). As an interpretation, inbound open innovation represents an amalgamation of how knowledge can move into the business. However, in order to describe inbound open innovation, it is useful to revert back to the diagram in Gassmann and Enkel (2004). Here, inbound open innovation describes the movement of knowledge and ideas into the firm from the external environment. Thus, linking back to the idea of leveraging the discoveries of others (Chesbrough, 2003; Chesbrough and Crowther, 2006). As noted by Chiaroni et al. (2011) and Bianchi et al. (2011), this involves the firm opening up and establishing relationships with external actors. In doing so, the firm will hope to gain access to technical and scientific competencies, with a view to improving innovation performance. von Hippel (1988) identified four useful external knowledge sources: (1) customers and suppliers, (2) universities, government and private labs, (3) competitors, and (4) other nations. Consequently, it is the firm's job to scan the external environment and source the most appropriate knowledge and/or technology (Inauen and Schenker-Wicki, 2011) to help improve their business. Typical organisational modes of inbound open innovation are: joint ventures, acquisitions, in-licensing, R&D contracts and research funding, purchase of technical and scientific services, minority equity investments, and non-equity alliances (Bianchi et al., 2011).

These methods described above relate to aspects of Rothwell's (1992) fourth and fifth generation innovation processes i.e. the use of joint ventures, collaborative research, and input from various actors in the supply chain. Therefore, the term of inbound open innovation provides a useful framing for how knowledge can enter the business, and the various forms that it can come in.

2.2.4 Outbound open innovation

Outbound open innovation is the movement of knowledge and ideas from inside the firm into an external organisation. It is useful to have an understanding of open innovation in its entirety, hence its brief inclusion. This act of technology transfer relates to the initial thoughts on open innovation (Chesbrough, 2003), whereby firms should not only look to commercialise technology from within, but also look for external organisations that may have a more suitable business model to commercialise that technology. Organisational modes of outbound open innovation include: spin-outs, licensing out IP, joint ventures for technology commercialisation, sale of innovation projects, supply of technical and scientific services, corporate venturing investments and non-equity alliances (Bianchi et al., 2011). The third dimension - the coupled process, relates to linking both inbound and outbound open innovation by working in alliances and/or joint ventures with complimentary partners (Gassmann and Enkel, 2004; Enkel et al., 2009).

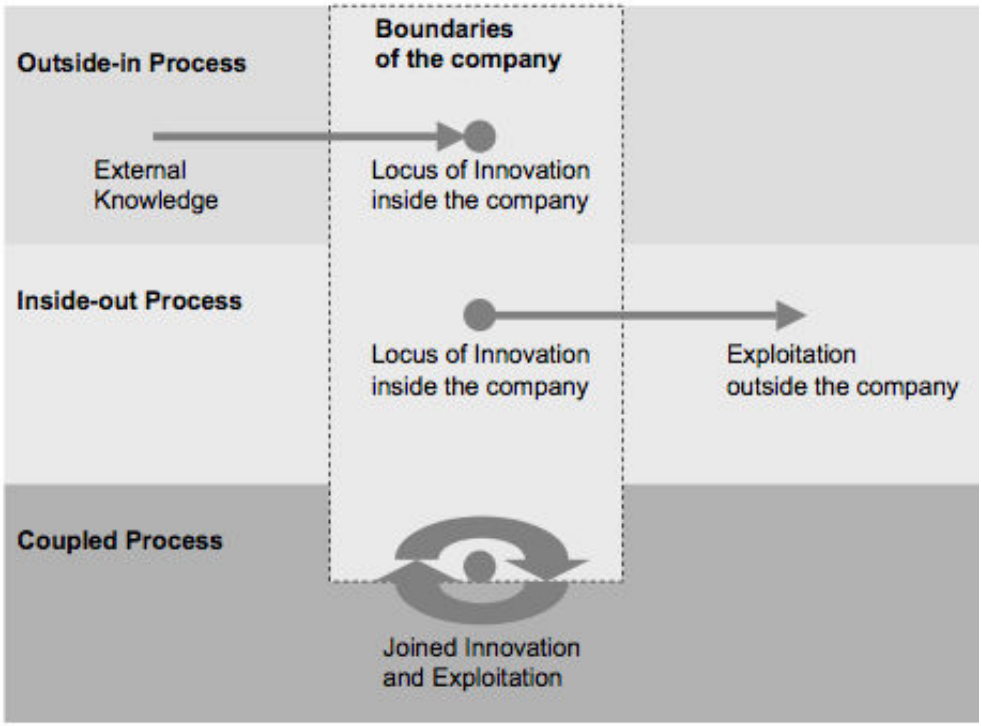


Figure 7: Dimensions of open innovation

Source: Gassmann and Enkel (2004, 6)

These three dimensions provide the initial make-up of open innovation. For firms to benefit from technology transfer, they need to develop capabilities in order to deal with inbound and outbound activities (Lichtenthaler and Lichtenthaler, 2010). Capabilities have been defined as 'complex bundles of skills and accumulated knowledge, exercised through organizational processes that enable firms to coordinate activities and make use of their assets' (Day, 1994, 39). This literature review notes that research on outbound open innovation has not received as much attention as inbound open innovation (Enkel et al., 2009; Kutvonen, 2011). However, as inbound activities typically reflect transactions that are more likely to occur in an organisation, it is anticipated that if a firm is going to make a strategic move towards OI, they may be more inclined to try and acquire knowledge. Therefore, as open innovation is still a comparatively new research subject, focusing research on its dominant area should give the greatest opportunity for uncovering how companies manage it. In an effort to convey a current state of the art with regards to open innovation, the remainder of this chapter outlines the different types of research that has already been done on open innovation and also identifies research gaps.

2.2.5 Trends in open innovation research activity

Since 2003, interest in open innovation has grown significantly (Gassmann, 2006; Huizingh, 2011; Bigliardi et al., 2012; Cheng and Huizingh, 2014), and academics have taken different paths for studying this phenomenon. Some work has asked the question whether or not open innovation adds value to the literature (Groen and Linton, 2010; Linstone, 2010; von Hippel, 2010; Badawy, 2011; Van de Vrande and

de Man, 2011). In addition, Mina et al. (2013) noted that most theoretical developments and empirical evidence is related to manufacturing firms, and less attention has been paid towards service organisations (Love et al., 2010; Chesbrough, 2011; Love et al., 2011). Other studies have tried to expand research on open innovation into industries outside of high-tech (Chesbrough and Crowther, 2006; Grimpe and Sofka, 2009; Spithoven et al., 2011; Vanhaverbeke, 2011) and others have combined different streams of management literature to open innovation so that the subject can be further developed (Grönlund et al., 2010). Moreover, research has investigated open innovation in the context of SMEs (van de Vrande et al., 2009; Lee et al., 2010; Zeng et al., 2010; Vanhaverbeke, 2011; Lasagni, 2012; Parida et al., 2012; Brunswicker and Vanhaverbeke, 2014). There has also been a trend towards case study research (Ili et al., 2010; Duarte and Sarkar, 2011), documenting various open innovation journeys (Huston and Sakkab, 2006; Chiaroni et al., 2011). Also, researchers have even focused upon specific geographical regions (Chen et al., 2011; Schroll and Mild, 2011). What remains clear is that open innovation is still in an embryonic state in research terms (Duarte and Sarkar, 2011; Schroll and Mild, 2011) and more empirical work is needed.

2.2.6 Gaps in current open innovation research

Through reading existing open innovation literature, it has been possible to identify gaps in current research. For one, a proportion of papers on open innovation have chosen to document how certain firms participate in open innovation. A selection of writings include: Chesbrough (2003), Bianchi et al. (2011), Mortara and Minshall (2011), Chiaroni et al. (2011), Huston and Sakkab (2006) and Lee et al. (2010). In terms of research, there are a few exceptions where firms have chosen to implement open innovation via a wholesale shift in corporate strategy e.g. Procter and Gamble (Huston and Sakkab, 2006). However, because open innovation includes so many features that were in existence before the term open innovation came around e.g. licensing agreements, alliances, joint ventures, R&D contracts, and research funding (Bianchi et al., 2011) – it is easy to say that open innovation can be observed in practice.

Such activities are indeed features of open innovation, but the gap in research asks the question – how many firms have a fully integrated, theoretically grounded, and managed open innovation system that is driven through corporate strategy? Instead of citing ‘open innovation’ because a joint technology partnership (or similar) has been observed in a company, thinking has to be directed towards strategy and change literature. Specifically, current literature fails to:

1. Explore the strategic adoption of open innovation
2. Offer options for measuring open innovation performance (Enkel et al., 2011; West et al., 2014)
3. Identify the challenges associated with pursuing open innovation (Hutter 2014)

Therefore, a gap in the literature exists to explore how companies can improve their open innovation operations and ultimately build up the literature into a place where open innovation can start to be professionalised in firms (Gassmann et al., 2010). This initial literature review has helped achieve a better understanding for what open innovation is (research objective 1). Through exploring background theory on open innovation, it has also been possible to identify a number of valuable research questions that will assist in developing open innovation theory:

RQ. 1 *How do firms currently innovate in slow clock-speed sectors?*
Multiple theoretical interests drove the development of this research question. Due to the fact that Rothwell (1992) and Tidd et al., (2001) already mentioned that external knowledge is important to drive success in a business, there is a desire to understand if and how companies have altered their practices towards an open innovation architecture (Chesbrough, 2003). Therefore, this research question is principally designed to scrutinise the extent to which companies have transformed themselves to reflect open innovation.

RQ. 2 *What are the capabilities and processes required for open innovation?*
As Chesbrough (2003) positioned open innovation as the new imperative for creating and profiting from technology, it is necessary for firms to be aware of how they can support this inside their organisation. The literature is only starting to ask the question of how companies can become better at open innovation through capabilities and practices (Hutter, 2014). Not only does this research question seek to develop current OI theory by identifying the necessary capabilities and processes required for successful open innovation, but it also has practical benefits for organisations that are interested in understanding open innovation.

RQ. 3 *What are the factors that affect the strategic implementation of OI?*
By recognising that companies operate under varying degrees of openness (Dahlander and Gann, 2010), and that there is a requirement to address the boundary conditions for open innovation (Linstone, 2010), this research question introduces the notion of corporate strategy. This research question explores the perception that if companies want to reach a professional level of open innovation (Gassmann et al., 2010), OI must be included into the company's strategy. Therefore, there is a requirement to understand the issues surrounding the implementation of OI. Furthermore, Hutter (2014) confirmed that little attention has been given towards the challenges associated with a firm pursuing open innovation. As a result, answers to this question will provide insight into this issue.

RQ. 4 *What should a model for strategic OI adoption include?*
At the 2014 EurOMA Conference, Wilhelm and Dolfsma (2014) noted that open innovation can become a value creating strategy, but only if organised appropriately (Wallin and von Krogh, 2010) via suitable organisational routines specific to open innovation. Accordingly, the literature on open innovation is starting to make that link towards strategy, and the output of answering this research question is to propose a tentative model for the strategic adoption of open innovation.

2.3 Conclusions

The aim of this chapter was for it to set out an argument in the subject of open innovation. To summarise, the process of innovation has changed over the years. Presently, companies are becoming much more aware of the benefits of using external parties within their innovation process. Consequently, it is necessary to try and provide mechanisms that offer firms the opportunity to improve their innovation process. Furthermore, innovation in product development is now acting as a key driver over competition. Therefore, being aware of the success factors for innovation is now imperative. Some success factors include: a willingness to take risks, a technological orientation, having a culture that promotes learning (Herrmann et al 2007), having effective linkages with external sources of scientific and technological know-how, a willingness to take on external ideas, involving all departments at the earliest stage possible (Rothwell 1992), and also having a strong orientation towards R&D, coupled with the acquisition of new technologies (Cooper 1984). In terms of open innovation, most favourable partners that can contribute to technological developments include universities and research institutes, suppliers, customers and consumers.

As a starting point on open innovation, it was important to begin by documenting how the concept came to pass, starting with the industrial setting in which it originated i.e. computing/high-tech industry. This helps to place founding thoughts about open innovation whenever the topic is expanded upon. Moreover, without introducing the concepts of closed and open innovation, highlighting their differences, and providing an key industry case example (P&G), it could become difficult to fully appreciate what is being discussed throughout the main body of the thesis. Therefore, the decision was made to include these aspects early on, including definitions, and the various activities involved in both inbound and outbound open innovation. This will help to become familiar with some of the language that is used in open innovation research. The chapter concluded by presenting the research questions of this study.

Crucially, this chapter has demonstrated the need for professionalising open innovation (Gassmann et al., 2010). Research is therefore required to better understand the capabilities needed for OI implementation. The forthcoming chapter about innovation will address relevant focal theory based upon the forgoing discussion on open innovation implementation requirements. These constructs will be developed.

Chapter 3. Literature review 2: Focal theory (Part I): Strategy

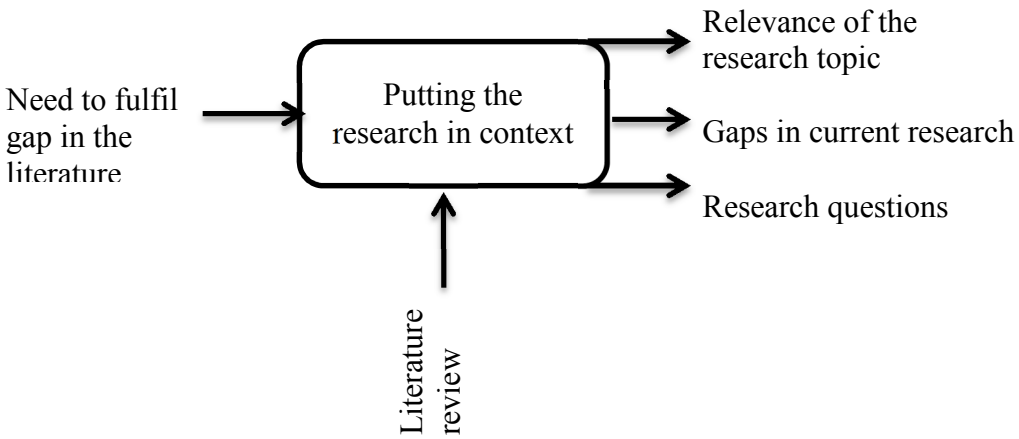


Figure 8: Chapter 3 input - output diagram

3.1 Introduction

The purpose of this chapter is to communicate what this research is about and why it is of importance. In doing so, it will become more apparent how the selected literature in this chapter is related to the research issue (i.e. how to become better at open innovation – 'designing a model of strategic OI adoption'). To do this, this chapter will be split up into two distinctive parts. Part I will be centred upon strategy literature, while part II concentrates on literature more commonly associated with operations management. As a starting point, part I begins with the idea of competitive advantage and what it means to hold competitive advantage (Peteraf and Barney, 2003; Katila et al., 2012; Schilke, 2013). Following this, there is a move towards a discussion on one of the most prominently acknowledged theories on strategy: dynamic capabilities (Teece et al., 1997; Teece, 2007). Part II is directed towards business processes (Slack et al., 2006; Slack et al., 2010) and maturity models. The final section of this chapter provides a summary of the literature covered, and explicitly shows the requirement for research into the identified gap in knowledge.

3.2 Scope of the literature review

This study brings together literature from different areas: *innovation* (Chesbrough, 2006; Laursen and Salter, 2006), *strategy* (Penrose, 1959; Teece, 2007*)*, *capabilities* (Teece, 2007) and *maturity* (Paulk *et al*., 1993). The task is to understand the implications of each of these areas for open innovation. As the aim of this research is to understand how the velocity of change in the external business environment impacts firms' strategic open innovation orientation, the roots of this study are in strategy literature. Moreover, because strategy and competitive advantage is about

moving to a superior position over rivals, combined with the fact that this thesis is concerned with improving open innovation performance, there is merit in investigating strategy literature as both are aimed at business performance. Consequently, this thesis presents and discusses three main contributions to the strategic management literature. After introducing the concept of competitive advantage, the focus turns towards Michael Porter and his five forces model. During this period in time (1980s), thinking on competitive advantage was directed towards company positioning within industry and the firm's ability to overcome influences of the five forces (external focus). However, an alternative view for achieving competitive advantage also emerged, termed the resource-based view (Penrose, 1959). This concept is directed towards organisational factors in obtaining competitive advantage (internal focus). Finally, Teece *et al*., (1997) introduced the concept of dynamic capabilities, advocating that it is the ability of the firm to change and adapt to changes in the external environment that will help them obtain competitive advantage over rivals (internal focus).

The connotations of innovation within the dynamic capabilities literature provide a suitable crossover to this study. Consequently, Teece's (2007) micro-foundations of dynamic capabilities are investigated further as they reflect an important part of the inbound open innovation process. For example, Laursen and Salter (2006) recognise that searching for external knowledge and technology is a vital component of open innovation. Accordingly, 'sensing opportunities and threats' is one of Teece's (2007) micro-foundations. The second micro-foundation is 'seizing', and once an external opportunity has been identified through a search process it is required to be seized upon. This requires literature on absorptive capacity (Cohen and Levinthal, 1990) and networks (Lee and Cavusgil 2006) to be explored further. By the firm engaging in R&D themselves, they should be more equipped to realise the potential of technological developments outside their own company walls. Thirdly, Teece (2007) proposes the 'transformation' process as the final micro-foundation of dynamic capabilities. Ultimately, when an external opportunity has been seized it is necessary to integrate this within the company. Therefore, this process requires certain internal resource alignment and configuration.

Once the strategy and innovation literature has been presented, theory on business processes and an evaluation of various maturity models is necessary in order to be in a position to answer the research questions. The theoretical framework for this study is explored in detail next.

3.3 Theoretical framework

'To be useful, a theoretical framework must be general enough to provide guidance in a variety of situations…It calls for sufficient generality and flexibility, so that the concepts can be applicable in a wide variety of circumstances. However, the theory must not be so general and academic that it has little to do with practical management problems' (Teece, 2011, 1).

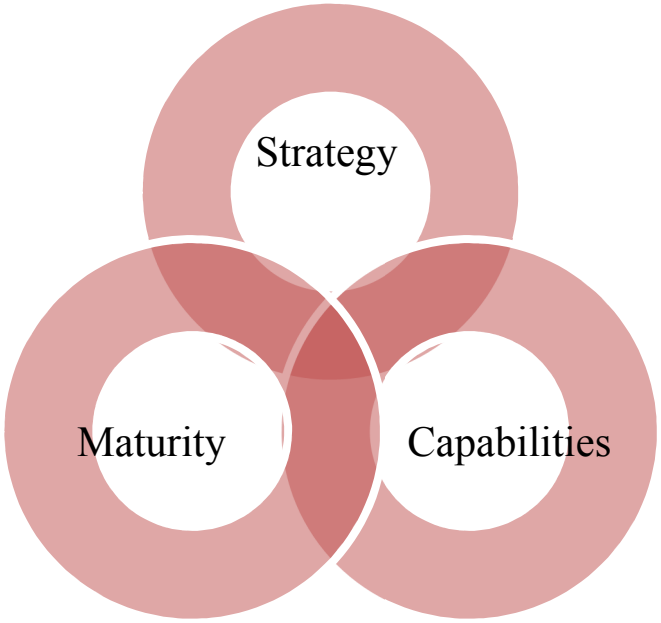


Figure 9: Theoretical framework

3.4 Strategy of the firm

3.4.1 Competitive advantage

Katila et al. (2012) contend that competitive advantage is at the heart of strategy. This view is supported by the fact that analysing the conditions for superior performance and competitive advantage represents one of the most prominent research themes within strategic management literature (Costa et al., 2013). According to Peteraf and Barney (2003), the existence of competitive advantage is when a firm experiences greater success than current and prospective rivals within its own operating industry. Also, an empirical indicator of competitive advantage can be typically found through superior firm performance relative to competing organisations (Schilke, 2013). What this means is that firms who are able to deliver products and/or services more effectively and efficiently to the market than their competitors are more likely to enjoy a position of competitive advantage.

The reality is that being different does not necessarily lead to competitive advantage, it comes from exploiting and maintaining a position ahead of their rivals

(Dess et al., 2007). Moreover, although much of the literature on strategy discusses sustained competitive advantage, Wiggins and Ruefli (2002) note that such outcomes are rare and short-lived. Increased rivalry encroaching into the realms of hypercompetition (D' Aveni, 1994) and rapid technological change (Bettis and Hitt, 1995) undermine firms abilities to achieve sustainable competitive advantage (Thomas, 1996). Consequently, competitive advantage is invariably transitory. Due to this, Sirmon et al. (2010) conclude that it is the job of management to understand the bases of competitive advantage and that they should focus on the factors that enable the firm to fill positions of temporary advantage. On the whole, the concept of competitive advantage has been rationalised through various guises e.g. cost leadership, differentiation, and internal resources (Perren, 2013) – the concept of clockspeeds will be addressed next in order to better position this research.

3.4.2 Clock-speed and strategic positioning

Fine (1998) noted that certain industries evolve faster or slower than others – this operational rate of activity is known as clock-speed. For example, software and mobile telephony is considered to be fast paced industries, with companies upgrading and evolving features on a continual basis to remain competitive resulting in short product life-cycles, whereas the petrochemical and aircraft industries are considered to operate in slow clock-speed terms. Enkel et al. (2009) also confirmed that companies in the fast clock-speed category have a higher number of joint research projects as opposed to companies in the slow-clock speed category, thus emphasising the impact that industry clock-speed has on firm openness. The importance of clock-speed in this research is acknowledged due to the impact an industry's speed of change has on a businesses decision to manage relationships with external parties (Harrigan, 1984) as well as its ability to innovate (Mendelson and Pillai, 1999). Noke et al. (2008) specifically references the upstream oil and gas industry as being a slowly evolving industry, with not as much tendency to be exposed to new businesses and ideas due to the restrained pace of the industry's clock-speed. Consequently, this must be taken in to consideration when analysing activity through an open innovation lens in this particular industry.

An industry's clock-speed i.e. the velocity at which changes in the external business environment occur (Mendelson and Pillai, 1999) will also have an impact on the strategic decisions a business makes. The variance in strategic direction between firms will also mean that decisions regarding how best to balance open or closed initiatives will need to be considered (Enkel and Bader, 2014). The original Miles and Snow (1978) strategy typology can be used to explore the relationship between strategic orientation and open innovation decisions. There are four separate positions a business can take: (1) Defender, (2) Analyser, (3) Prospector, and (4) Reactor.

Firms following one of the three positive/proactive strategies succeed in their market and as a result of changing their processes and methodologies accordingly will have a robust financial performance (Fiss, 2011). In contrast, the reactor, who has a non-proactive strategy, simply reacts to changes that occur without having a strong link between structure and strategy. In a recent study, Bader and Enkel (2014) produced

the opportunity-seeking prospector, the dual-orientated analyser, and the market segment securing defender. By revisiting the proactive strategic directions from Miles and Snow (1979), Bader and Enkel (2014) were able to combine an innovation orientation mechanism to help better understand a firm's choice for openness based on strategic direction.

	Defender	**Analyser**	**Prospector**
Internal structures and processes	- Formalised processes and legitimised management principles - Controlled actions and operations	- Degree of centralisation and formalisation might be high or low	- Informal structures and flexible processes - Low adherence to predefined practices and operations so as to quickly adapt to external changes
Market and innovation orientation	- Tight product market domain - Little quest for opportunities beyond own sector - Focus on internal process optimisation and cost-efficient core technology - Market segment leader - Cost leadership or focus on niche - Tendency towards incremental innovation	- Dual technological core (hybrid strategy) - Differentiation or cost leadership depending on product category - Increase of novelty and reduction of R&D risks/costs as two objectives - Both incremental and radical innovations	- Broad product market domain - Continuous quest for opportunities beyond own sector - Trigger for change and novelty in dynamic environment - Willingness to take risks - Technology leader - Differentiation strategy - Tendency towards radical innovations

	Market segment securing defenders	**Dual-orientated analysers**	**Opportunity-seeking prospectors**
Expected open innovation behaviour	- Focus on internal development with few open innovation initiatives (predominately intense customer relationships in existing markets)	- Combination of defender and prospector characteristics in collaboration behaviour and following innovation model	- Utilisation of various open innovation formats aiming for novel innovation opportunities
	Tendency towards closed innovation model		Tendency towards open innovation model

Table 4: Revised strategy typology of innovation management

Bader and Enkel (2014)

The market segment securing defender focuses on a narrow product market portfolio, and is able to achieve control over a particular market segment as the firm focuses on cost leadership, internally optimising their processes and structure and resource efficiency (DeSarbo et al., 2005). Such firms may differentiate themselves in the marketplace via perceived quality improvements or branding (Bader et al., 2014). Based on their characteristics, in-house development prevails. Therefore, these firms are more skewed towards the closed innovation spectrum, and only very rarely opt for an open approach using external sources of knowledge (Bader and Enkel, 2014).

In between the market securing defender and opportunity seeking prospectors sits the dual-orientated analysers (a hybrid of both strategy types). These firms make calculated decisions about its market and innovation orientation. For instance, cost leadership and market segmentation may be particularly important in one instance, however in other situations, a differentiation strategy and technology leadership may apply (Bader and Enkel, 2014). Based on the hybrid mentality of the dual-orientated analyser, the firm will attempt to balance exploration and exploitation activities (March, 1991; Bader and Enkel, 2014). Not only will the firm seek to exploit its internal resource capabilities, but it will also seek out external sources of knowledge to enhance existing capability the firm possesses. For example, technical solutions that exist in other sectors may be identified, analysed, and if suitable, brought in to address challenges that the firm is experiencing (Bader, 2013; MacKinven, 2015). Overall, the dual-orientated analyser will need to manage its resource allocation effectively (Miles and Snow, 1978) while pursuing this internal and external orientated strategy in order to extract maximum value. This type of firm will not be an open as the opportunity prospector. Instead, they will be much more tactile in deciding when and whom to open up with (Bader and Enkel, 2014).

The opportunity prospector can be viewed at the most extreme end of the openness spectrum, intensely exchanging information with outsiders and continuously looking for novel technologies and monitoring changes in market trends. External searching /scouting (Whelan et al., 2011) is particularly important for this type of firm, and they draw upon a wide range of open innovation activities (Bader and Enkel, 2014). Not only does the opportunity prospector search for technological solutions and novel concepts, but they also try to source new business model ideas that cross industry boundaries (Gassman and Enkel, 2010). A serious point to note is that too much propensity towards open innovation i.e. over-searching (Laursen and Salter, 2006) may be to the detriment of the business, neglecting analysis on the cost-to-benefit ratio (Miles and Snow, 1978).

Considering these options in the context of a slow clock-speed industry is vital when investigating a firm's strategic positioning towards open innovation activity. The dynamic capabilities framework proposed by Teece (2007) offers a suitable vehicle to analyse open innovation maturity.

3.4.4 Dynamic capabilities

Dynamic capabilities are separate, but interlinked to operational capabilities (Easterby-Smith and Prieto, 2008; Pavlou and El Sawy, 2011), which enable the firm

to make a living at present (Winter, 2003). As indicated by Helfat and Winter (2011, 1244), operational capabilities relate to the firm being able to undertake 'an activity on an on-going basis using more or less the same techniques on the same scale to support existing products and services for the same customer population'. FutureSME (2008) assert that operational capabilities are 'the ability to align critical processes, resources and technologies according to the overall guiding vision and customer focused value propositions coupled with the ability to deliver these processes effectively and efficiently.' Essentially, operational capabilities maintain the status quo (Stadler et al., 2013). Dynamic capabilities are a firms ability to change and align to the external environment (Zahra et al., 2006). Dynamic capabilities thus enable a firm to alter the ways in which they currently earn a living (Helfat and Winter, 2011).

Teece et al. (1997, 516) defined dynamic capabilities as 'the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments'. This original construct was developed in order to help answer the question of '*how firms achieve and sustain competitive advantage*' while '*operating in environments of rapid technological change*' (Teece et al., 1997). In contrast, Eisenhardt and Martin (2000) claim that dynamic capabilities are necessary in moderately dynamic markets, and also claim that dynamic capabilities can be a source of advantage, just not sustainable advantage. They define dynamic capabilities as 'the firm's processes that use resources – specifically the processes to integrate, reconfigure, gain and release resources – to match and even create market change…and are the organizational and strategic routines by which firms achieve new resource configurations' (Eisenhardt and Martin, 2000, 1107). What is more, Helfat and Winter (2011) assert that dynamic capabilities are used regularly by firms, and are even important in relatively stable environments. Further to this, a recent empirical study by Schilke (2013) investigating the relationship between dynamic capabilities and competitive advantage showed that competitive advantage is strongest during intermediate levels of dynamism, and comparably less so in times of low or high dynamism. Helfat and Winter (2011) conceded that an assessment of change in the external environment will more than likely be based on a matter of opinion and expertise.

In terms of this thesis, if one was questioning whether or not the oil and gas industry represented a changing environment - Stadler et al. (2013) recently undertook a study on dynamic capabilities in this industry, and suggested that the external environment of this industry has shifted from a relatively stable state to one that is much more variable. However, to continue the discussion on defining dynamic capabilities, Helfat et al. (2007, 4) provide a much more refined definition than previous offerings (Wilden et al., 2013), proposing that dynamic capabilities represent 'the capacity of an organization to purposefully create, extend, or modify its resource base.'

The definition by Helfat et al. (2007) offers a suitable link towards a discussion on dynamic capabilities and performance. To be explicit, dynamic capabilities do not in themselves lead to superior performance (Eisenhardt and Martin, 2000; Helfat and Peteraf, 2003; Shamsie et al., 2009; Wilden et al., 2013). This ideology creates a

tautology between dynamic capabilities and performance. Such thinking was one of the reasons why dynamic capabilities were so heavily criticised initially (Helfat, 2013). As a result, to qualify as a capability (dynamic or operational), a capability needs to demonstrate a minimal standard of performance (Helfat et al., 2007; Stadler et al., 2013). There is no guarantee that dynamic capabilities will be deployed in a manner whereby internal organisational elements are in congruence with one another and suitably aligned to external environmental conditions (external fit) (McKee et al., 1989). This has led to Bititci et al. (2011) proposing that it is in fact the managerial processes (set direction, manage strategy, build organisational competence, manage performance, and manage change) that sustain performance in the long term. Without successful management, no matter how dynamic the routines and processes, the firm will be unable to perform at a high level.

In terms of gaining a deeper understanding for what dynamic capabilities are, on the most general level they represent organisational processes (Helfat et al., 2007) or routines (Zollo and Winter, 2002). According to Winter (2003, 991), a routine is a 'behaviour that is learned, highly patterned, repetitious, or quasi-repetitious, founded in part in tacit knowledge – and the specificity of objectives'. Helfat and Peteraf (2003) stress that in order for a capability to be considered a dynamic capability, the capability must change the resource base, as well as be embedded within the firm and have the potential to be repeated. They also state that, 'at minimum, in order for something to qualify as a capability, it must work in a reliable manner' (Helfat and Peteraf, 2003, 999). Moreover, dynamic capabilities constitute an ability to get rid of decaying resources or recombining them in new ways that are more beneficial to the firm (Simon and Hitt, 2003).

All of the above may sound confusing, and in places, somewhat inconsistent (Ambrosini et al., 2009). Ultimately, this has been a large criticism of the dynamic capabilities literature (Hine et al., 2013; Li and Liu, 2014). For Hine et al. (2013), there is too much ambiguity around capability types, and as a result, they deconstructed seminal papers on capabilities, reconstructed their contributions, and developed a three tiered hierarchy of capabilities (see figure below). At the top of this hierarchy lies '*dynamic learning capabilities'* – a higher order capability. This incorporates the overlapping dynamic capability definitions from Teece *et al*. (1997); Zollo and Winter (2002); Winter (2003); Helfat *et al*. (2007); Teece (2007) (table below), aligning to Collis's (1994) third level of metaphysical, creative and learning ability. This is due to the fact that their definitions concentrate on the creation of new capabilities to impact on firm output and performance.

'The firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments.'	Teece et al. (1997)
'A dynamic capability is a learned and stable pattern of collective activity through which the organization systematically generates and modifies its operating routines in pursuit of improved	Zollo and Winter (2002)

effectiveness.'	
'One can define dynamic capabilities as those that operate to extend, modify or create ordinary capabilities.'	Winter (2003)
'The capacity of an organization to purposefully create, extend, or modify its resource base.'	Helfat et al. (2007)
'Dynamic capabilities can be disaggregated into the capacity (1) to sense and shape opportunities and threats, (2) to seize opportunities, and (3) to maintain competitiveness through enhancing, combining, protecting, and, when necessary, reconfiguring the business enterprise's intangible and tangible assets.'	Teece (2007)

Table 5: Dynamic capability definitions

Dynamic learning capability can be associated with creativity, experimentation, change, adaptation, ability to combine specialised resources, flexibility, explorative learning, and strategic intent focused on sustainability and long term growth (Hine *et al*., 2013). Below dynamic learning capabilities in the hierarchy sits '*dynamic functional capabilities'* – a lower order capability (Hine *et al*., 2013). These capabilities are also dynamic and change focused, but created through learning mechanisms, therefore suggesting that they should be placed beneath dynamic learning capabilities (Hine *et al*., 2013). This level of capability is associated with resource specialisation, routine flexibility, explorative and exploitative learning, and sustainable competitive focus (Hine *et al*., 2013). Finally, and with no change to existing contributions, the hierarchy is built up from '*ordinary capabilities'*, a non-change focused first order capability (Hine *et al*., 2013) that requires the firm to have a minimum level of capability to perform every day tasks.

These three levels are to be considered across four internal dimensions (representing major thematic areas in the capability/strategy literature) namely, prominent resources; routine patterning; focus of learning; and strategic intent. Moreover, the external component of this model is related to the level of volatility or dynamism in the competitive market. According to Hine *et al*. (2013), the conditions in the external environment determine the requirement for firms to have dynamic learning capability, dynamic functional capability, or operational level capabilities.

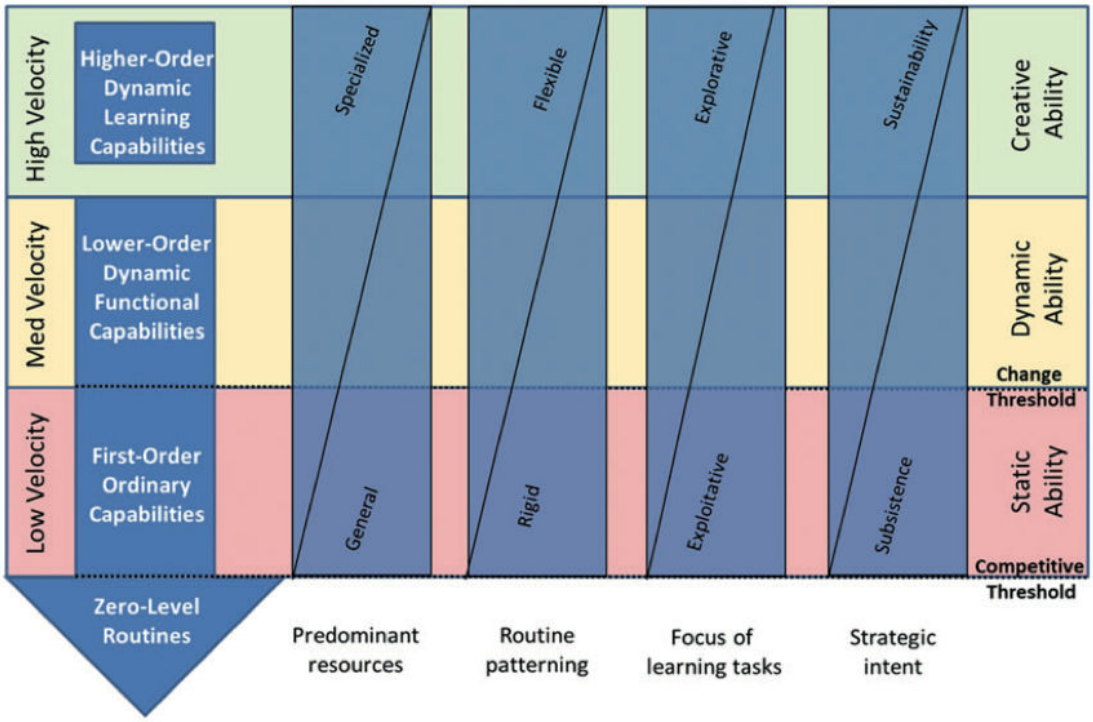


Figure 10: Integrated capability framework

(Hine *et al*., 2013)

Conclusively, the idea behind dynamic capabilities is about how closely the firm can align internal and external resources to the changing external environment. If the firm can do this successfully, then dynamic capabilities can positively influence firm performance (Teece et al., 1997). However, as a theoretical construct, Dixon et al. (2014) confirm that dynamic capabilities is still under developed. A particular dynamic capability that relates to innovation is the sensing, seizing, and transforming activities described by Teece (2007). These three distinct features make up dynamic capabilities. Taking an organisational process perspective will help uncover the necessary capabilities required for inbound open innovation (Ridder, 2011). The framework that underpins this research can be seen in the figure below. The usefulness of this framework has also been expressed by Jantunen et al. (2012) in their study on dynamic capabilities.

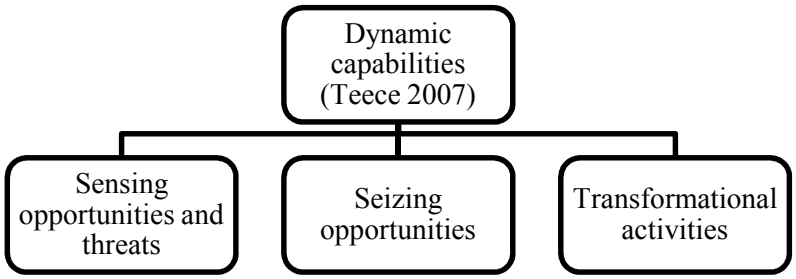


Figure 11: Dynamic capabilities framework for empirical research

3.4.4.1 Sensing external opportunities

To begin the process of understanding how firms engage in open innovation (associated with RQ. 1), it is necessary to explore the literature on search activities as the focus of open innovation is on searching for new ideas (Badawy (2011). Firstly, Teece (2007) noted that the nature of capabilities is founded on the ability to *sense opportunities and threats.* More recently, Teece (2011, 1) mentioned that sensing is concerned with the 'identification and assessment of an opportunity.' Ultimately, this relates to scanning, creativity, learning and interpretive aptitudes, a view previously highlighted by March and Simon (1958); Nelson and Winter (1982). Instead of having such cognitive traits existing in a few individuals within the firm, the dynamic capabilities perspective believes that the firm would be better placed to have organisational processes, which can collect new technological developments from the internal and external business environment, and monitor customer needs in order to identify new product opportunities (Teece, 2007). Consequently, it is possible to see how these ideologies relate to search activities for open innovation, and indeed local versus distant search. Moreover, Teece (2007) suggested that firms must search for ideas within their core area as well as beyond their immediate periphery. Furthermore, Bititci et al. (2008) and Maguire et al. (2008) proposed that environmental scanning is an important activity firms should undertake, as this can assist in the process of achieving sustained competitive advantage. Sofka and Grimpe (2010) propose that managers should in fact develop specialised search strategies to help the firm achieve innovation success. As such, Ridder (2011) recognised the need for firms to develop external sensing capabilities in order to overcome the inertia and myopia of not being able to recognise external transfer opportunities and the nuisance of failing to capitalise on technologies available within or outside the firm. Consequently, search processes or routines have previously been noted as being critical for dynamic capabilities (Tripsas and Gavetti, 2000).

As Laursen and Salter (2006); Li-Ying et al. (2014); West and Bogers (2014); Wilhelm and Dolfsma (2014) note, a key aspect of the innovation process is the act of searching for new concepts that have promising commercial potential. Thus, with a substantial proportion of the open innovation paradigm being weighted towards external actors, search activities become a particularly important topic to address during the literature review on open innovation. The first notable reading that highlights a firm's search activities is that of Nelson and Winter (1982). This text emphasises the role of search in order to assist firms with finding diverse sources of knowledge that may facilitate the development of new technologies. Interestingly, Chesbrough and Crowther (2006) made reference to this work, providing further evidence that the facets of open innovation have been said before.

There are two search options available to the firm - internal search and external search activities. Giarratana and Mariani (2014) note that in areas of high absorptive capacity and significant R&D investments, the firm needs to calibrate the degree to which they use knowledge internally vs acquire externally due to fears over imitation and appropriability. This section of the thesis first discusses internal search. Katila and Ahuja (2002, 1183) conducted a study whereby the aim was to test if a firm's ability to create new products was correlated to search depth and search scope. Katila and Ahuja (2002) describe search depth as 'how deeply a firm reuses its existing

knowledge' and search scope is 'how widely a firm explores new knowledge'. Furthermore, Katila and Ahuja (2002) proposed that one or a combination of search activities impacts a firm's innovative performance. To test their hypotheses, they gathered new product data and patent data from a selection of 124 industrial robotics firms across Europe (19), Japan (78), and North America (27). Information regarding new product introductions was gathered from robotics and trade magazines, and product catalogues, while patent data was collected from the United States Patent and Trademark Office. This study has not been as widely acknowledged in open innovation research if compared to citations on the work of Laursen and Salter (2006), which look at the firm searching outside their company for new ideas.

Laursen and Salter (2006) acknowledge that their study builds upon the prior work conducted by Katila (2002); Katila and Ahuja (2002). As previously mentioned, there are two strands to search activities, and Laursen and Salter (2006) focus upon external search. The main premise of their study was to find out what impact external search has on innovative performance. Like Katila and Ahuja (2002), two concepts were developed to highlight the extent of external search activities – search breadth and search depth. The first concept is related to volume, which is essentially the number of external sources the firm draws upon for innovative purposes. The latter concerns the intensity to which the firm extracts knowledge from various external sources (Laursen and Salter, 2006). Although Laursen and Salter's (2006) work largely focuses on innovation performance, they do not directly provide a definition for it. However, looking at their section on measures, it is possible to highlight the three proxies they consider reflects innovation performance. The first variable they use to indicate the ability of a firm to develop radical innovations is measured as a fraction of turnover related to new product introductions to market. To reflect incremental innovation, they use two variables: (1) a fraction of turnover related to new products and (2) a fraction of turnover related to significant product improvements. Within the paper, 4 hypotheses are presented and tested against data generated from the 2001 UK innovation survey. Results indicate that searching widely and deeply has a positive effect on innovative performance up to a point; findings supported by Garriga et al. (2013). The original study shows that the peak number of external sources a firm can search for and still have a positive relationship with innovation performance is 11 external sources; tapping into excess of 11 external sources for innovative purposes has negative consequences. Therefore, confirming that over searching can have a negative influence on innovative performance, thus echoing the findings in Katila and Ahuja (2002). In addition, Dahlander and Gann (2010) simply suggest that some firms devote too much time scanning external sources for innovations. Nevertheless, their statement is not without reasoning, as evidenced by the curvilinear relationship between the search for new innovations and innovative performance (Katila and Ahuja, 2002). Consequently, firms need to find a way of striking a balance that allows them to benefit from their search activities whilst not putting themselves at a disadvantage (Berchicci, 2013; Li-Ying et al., 2014). Yet, it should be remembered that studies based on Community Innovation Surveys only provide simple accounts of external sources and partnerships (Hsieh and Tidd, 2012). Here, it is possible to see that work has to be done on identifying improvement processes for this area,

subsequently making it possible for firms to improve this aspect of their innovation process.

As highlighted by Dahlander and Gann (2010); Brunswicker (2011); Bellantuono et al. (2013), firms have varying degrees of openness. Research has shown that the orientation of a firm is important in deciding who a firm will try to partner with (Chen et al., 2011). For instance, Chen et al. (2011) separate their study between innovation modes of *science, technology and innovation* (STI) and *doing, using and interacting* (DUI). The STI mode is more focussed towards scientific knowledge, whereas the DUI mode is more reliant on experience-based learning and know-how (Jensen et al., 2007). This particular study marks an extension to the already discussed work of Laursen and Salter (2006). Chen et al. (2011) acknowledged search depth and scope as a reflection of firm openness, but also included a third dimension – search orientation. This is a particularly useful addition on search strategies, as partner selection is pivotal to firm success in collaboration.

Moreover, findings reveal that STI and DUI modes require different types of partners to commercialise technology. Again, verifying the claims made by Laursen and Salter (2006), Chen et al. (2011, 371) also find that there is an optimal number of partners which a firm can partner with until it becomes counterproductive. They also state that 'increasing the diversity of partners improves a firm's innovative performance'. It must be recognised that this statement is similarly reflected in the number of recommended firms a company can collaborate with until it becomes damaging for the firm. This number of optimal partners rests at 8.7 (Chen et al., 2011). However, as this study was conducted via quantitative methods, it would be additionally useful to gain a deeper insight through qualitative analysis, as this would provide support to the quantitative findings.

Building on this discussion on search activities, the work of March (1991) reflects an important aspect of a firm's search strategy. March (1991) introduced two concepts which highlight the options available to firms wishing to introduce products to the market. One half of the two concepts is termed exploration, which 'includes things captured by terms such as search, variation, risk taking, experimentation, play, flexibility, discover, innovation' (March, 1991, 71). While the other term, exploitation 'includes such things as refinement, choice, production, efficiency, selection, implementation, execution' (March, 1991, 71).

Companies that follow an exploration strategy will look for partners with distinctly different capabilities, and outside their core technological field in a different industry sub-sector (Dittrich and Duysters, 2007). A key aspect of exploratory relationships is learning (Koza and Lewin, 1998), and therefore, both firms involved must see potential for learning from one another, otherwise the appetite for collaboration may be diminished (Sen and Egelhoff, 2000). Also, in an exploration strategy, firms will typically establish alliances characterised by weak ties (Granovetter, 1973). This simply means that commitment levels are lower than in other types of alliances, and subsequently allows the firm to explore other partnership opportunities simultaneously (Dittrich and Duysters, 2007). Afuah (2000) noted that weak ties are especially relevant for industries that experience

conditions of rapid technological change. While, on the other hand, companies pursuing an exploitation strategy may find that strong ties are more effective, and will search for companies with similar technological capabilities. Exploitation requires intense collaboration, which takes considerable time to build up, and benefits will accrue only after long-term collaboration (Dittrich and Duysters, 2007). Essentially, exploration and exploitation, and local versus distant search (Ahuja and Lampert, 2001; Benner and Tushman, 2002) represents the search for capabilities that are close or distant to the focal firm's current skills and capabilities. Such an argument supports the view that weak ties are more appropriate for exploration, while developing strong ties are more suited for exploitation activities (Gronum et al., 2012). Therefore, either option will have its own particular impact on innovation performance. Gibson and Birkinshaw (2004) note that high performing organisations are ambidextrous, performing both explorative and exploitative R&D activities (Mudambi and Swift, 2014).

Expanding on this, Chang et al. (2012) focus on four organisational capabilities for improving innovation performance. In particular, they address the concept of openness capability. As highlighted by McLaughlin et al. (2008), gathering a wide array of ideas is essential for successful innovation, and even more important for firms wishing to create radical innovations. This opinion is reflected by Iansiti (1997) who stated that integrating internal and external technologies is required to remain competitive in the market. Chang et al. (2012, 444) state that 'searching openness capability refers a firm's ability to search sources of radical innovation with external, distant and wider orientation rather than internal, local and narrow sources'. Bessant and Tidd (2008) reinforce the notion of search activities, highlighting the potential fruitfulness of looking in unfamiliar places and building relationships with firms that would previously have never been considered or thought of. Watts (2001) continued this sentiment, suggesting that inhibitors for radical innovation include limited organisational searching, a view similarly supported by Chiang and Hung (2010). Moreover, Stringer (2000) noted that devoting significant efforts towards internal R&D and existing networks, instead of pursuing new external sources and external networks prevents firms from recognising new ideas for radical innovation.

The fundamental idea is to continually challenge the 'normal' approach to innovation, and this may lead to discovering something completely new. Moreover, Teece (2007) argued that local search alone is not sufficient, and that firms must search for innovative solutions beyond the immediate business periphery. Such sources of innovation include universities and research institutes (George et al., 2002; Chesbrough, 2003; Cassiman et al., 2010; Buganza et al., 2011; Duarte and Sarkar, 2011), suppliers (Li and Vanhaverbeke, 2009; Schiele, 2010), customers (Gassmann et al., 2006; Inauen and Schenker-Wicki, 2011), and complementary firms (Teece, 2007). With the purpose of this research being to find ways of improving innovation performance, this section on firm openness is required in the review to help build a platform for thinking around the concept of looking in local and distant areas for new technology.

Various options exist for firms to engage in search activities. Specific ways include the utilisation of technology scouts (Ili et al., 2010; Rohrbeck, 2010). These individuals can either be employees of the firm or consultants (Dougherty, 1989; Wolff, 1992). Similar to the characteristics of the technological gatekeeper, technology scouts must be: knowledgeable in science and technology, lateral thinkers, imaginative and cross-disciplinary orientated (Wolff, 1992). Their role, through a systematic process (Rohrbeck, 2010) is to identify relevant technologies in the external environment. Conversely or simultaneously, firms can also choose to use innovation intermediaries (West and Lakhani, 2008; Jeppesen and Lakhani, 2010; Lee et al., 2010; Tran et al., 2011) such as InnoCentive, NineSigma, and Yet2.com. These platforms act as brokers where the firm can post technical problems in the anticipation that an external actor is able to provide a solution. The availability of information and communication technologies has made the search process much more inclusive (Dodgson et al., 2006). Online communities (Dahlander and Wallin, 2006), crowdsourcing (Ebner et al., 2009), and Internet platforms (Droge et al., 2010) are all features of the open innovation paradigm. In Ili et al. (2010), one of their automobile cases highlights that one of the firms chose to install a project team and distribute individuals all over the world to pick up relevant information about hybrid technology, a strategy similarly adopted by P&G and the use of their Technology Entrepreneurs (Dodgson et al., 2006). Further, continuing on the idea of web-based tools, companies also choose to host areas online where individuals can submit innovative ideas (Piller and Walcher, 2006) e.g. both BMW and Volkswagen offer these online spaces (Ili et al., 2010).

In reflection of the immediate section on firm openness, there are several notable points worth capturing. Firstly, openness is concerned with the degree of openness that a firm has towards external ideas (Dahlander and Gann 2010). While Chesbrough (2003) has argued that increased openness is beneficial to the firm, caution must be taken, as he was the one who introduced the term open innovation. However, much of the literature is in favour of utilising external sources of knowledge in the innovation process. In terms of relevance to this thesis in identifying capabilities for inbound activity, Chang et al. (2012) investigated what capabilities are required for developing radical innovation. They argued that firms interested in pursuing radical innovation were required to search sources of distant orientation, and proposed an 'openness capability'. Teece (2007) also advocated that firms must look locally as well as in unrelated industries. Crucially, search processes facilitate seizing opportunities (Ridder, 2011).

3.4.4.2 Seizing external opportunities

Building on from sensing opportunities and threats, Teece (2007) discusses *seizing opportunities*. This is the ability of the firm to assimilate and integrate knowledge for commercial gain. Teece (2011, 1) asserts that seizing is the 'mobilization of resources to address an opportunity and to capture value from doing so.' Essentially, this is the act of capitalising on a sensed opportunity or threat. Moreover, Jantunen et al. (2012) also recognised that seizing and knowledge integration is conceptually close to that of absorptive capacity.

The term absorptive capacity was introduced by Cohen and Levinthal (1990). The importance of this concept in relation to open innovation is due to its association with external knowledge and firms realising the value of new technologies being developed outwith their own company that may be of practical use to them (Berchicci, 2013). The paper, *Absorptive capacity: a new perspective on learning and innovation* proposed that external sources of knowledge are frequently important to the innovation process within a firm. Furthermore, it was also stated that a firm's innovative capability was a critical component to exploiting external knowledge. Consequently, it is possible to see how this links to the concept of open innovation and why other academics have noted its importance within the literature. The main aspect of absorptive capacity is related to the level of prior related knowledge. Cohen and Levinthal (1990) argued that if an individual has a high level of prior related knowledge in a field, they will have a greater ability to evaluate (Arora and Gambardella, 1994; Chiaroni et al., 2010; Ili et al., 2010) and utilise external knowledge than someone without that prior related knowledge. This 'prior related knowledge confers an ability to recognize the value of new information, assimilate it, and apply it to commercial ends' (Cohen and Levinthal, 1990, 128).

By conducting R&D, firms further develop their understanding in scientific fields, and during this process they have the ability to identify technology crossover applications for their own products. In order to assimilate this information (absorb and understand it), firms may employ mechanisms whereby knowledge can be freely shared throughout the organisation e.g. online knowledge exchange portals. Through deepened learning and knowledge exchange, firms will be better positioned to predict market trends and exploit external pre-commercialisation stage research by offering products to customers that are aligned to future market requirements (Lane et al., 2006). These collective abilities are what constitute the original definition of absorptive capacity. Fundamentally, Lane et al. (2006) suggest that the combination of these dimensions enables a firm to replicate other firms' products or processes, as well as provide them with an ability to exploit early stage research. By nature of academia, others have sought to provide alternative definitions of absorptive capacity e.g. Mowery and Oxley (1995); Kim (1997a); Kim (1997b); Zahra and George (2002).

Zahra and George (2002) set out to review the literature on absorptive capacity and redefined the term. They suggest that absorptive capacity is 'a set of organizational routines and processes by which firms acquire, assimilate, transform, and exploit knowledge to produce a dynamic organizational capability' (Zahra and George, 2002, 186). As an interpretation, these activities seem to be weighted towards being embedded within the organisational culture through people, processes, and structures. Also, such features resonate with the dynamic capabilities literature proposed by Teece (2007). Furthermore, although Zahra and George (2002) omitted the section about valuing *new* knowledge from Cohen and Levinthal (1990) within this definition, the activities they describe could be implied to mean both new and existing knowledge, by nature of the activities described. However, the distinction is not clear.

Building on from this, they divide absorptive capacity into 'potential' absorptive capacity i.e. acquiring and assimilating, and 'realised' absorptive capacity i.e. transforming and exploiting. Consequently, this definition is built on four dimensions. Moreover, they also interjected the idea of social integration mechanisms, whereby the four dimensions are made up of social interactions. This might be seen as a portfolio of relationships, possibly relating to a key capability of the firm. In addition, certain behaviours are dependent on key people and relationships within a firm. However, at the same time, it is important to embed such behaviours within the organisation. Most significantly, this is due to the fact that people can leave the organisation, and as they leave, so too does the knowledge within them. Thus, these dimensions are affected by the social integration between them (Zahra and George, 2002; Todorova and Durisin, 2007) and other firms (Dyer and Singh, 1998).

Although Zahra and George (2002) attempted to provide an extension to absorptive capacity (Cohen and Levinthal, 1990), their work is heavily criticised by Todorova and Durisin (2007). Firstly, Todorova and Durisin (2007) suggest that insights from the original concept of absorptive capacity are not included. In addition, they argue that important research contributions on learning and innovation are also missing. This contrasts to the work of Lane and Lubatkin (1998), who duly noted the earlier work of Cohen and Levinthal (1990) and sought to add value by reconceptualising the firm-level construct of absorptive capacity, as the original definition suggests that firms have equal capacity to learn from all other organisations (Lane and Lubatkin, 1998). However, Lane and Lubatkin (1998) argued that learning depends on the similarity of knowledge bases between the receiving and transferring firm. Hence, the knowledge base in a firm is particularly important in its ability to identify new and potentially valuable outside knowledge (Spithoven et al., 2011). For this reason, Spithoven et al. (2011) contend that the work of Cohen and Levinthal (1990) and Lane and Lubatkin (1998) are both fundamentally important in understanding each dimension of absorptive capacity.

The definition provided by Cohen and Levinthal (1990) suggests that in order for a firm to benefit from inbound open innovation, the focal firm is required to have a substantial level of prior related knowledge. For example, in order to become aware of the value that external knowledge can have on the business, the firm must continue to develop their own capabilities. If a firm does not attempt to generate absorptive capacity, they are putting themselves at a disadvantage, as they are not improving on existing technical knowledge. Therefore, individuals may not be as readily aware of the advantages that a particular external knowledge could have at improving firm performance.

Accordingly, absorptive capacity can be created in several ways:

- Conducting internal R&D (Cohen and Levinthal, 1990)
- Investing in manufacturing (Cohen and Levinthal, 1990)
- Attending advanced technical training (Cohen and Levinthal, 1990)
- Calling upon third parties e.g. collective research centres (Spithoven et al., 2011)

Absorptive capacity is rooted in the importance of the firm conducting R&D themselves, and by doing so, increasing their awareness of technological developments outside their own walls. However, overall, if one was to really analyse absorptive capacity and inbound open innovation side by side, it could be particularly difficult to separate the two constructs, a view similarly shared by Hagedoorn and Wang (2012). For instance, knowledge assimilation is regarded as a key element of absorptive capacity, and is defined as a firm's process for analysing, interpreting, and understanding external knowledge and integrating it with internal know-how (Zahra and George, 2002; Todorova and Durisin, 2007). Therefore, this definition is very close to the key activities for inbound open innovation i.e. sensing an opportunity, seizing it, and integrating it within internal operations. Therefore, it is possible to see how closely related other aspects of management literature are to open innovation.

In terms of information flows, when information comes into a firm from the outside, it is not firm-specific in nature (Keil, 2004). Therefore, co-ordinating and integrating this within the firm's boundaries constitutes as a distinctive organisational capability (Lorenzoni and Lipparini, 1999). In addition, Grant (1996) asserted that whatever knowledge or information that filters into the firm needs to be translated into a firm-specific, idiosyncratic knowledge form that is understood by its new users. Also, in accordance with Ridder (2011), if external knowledge is brought into the firm, adapted in such a way that internal employees can better understand it, there is a greater chance of it being put into use, thus conferring to an inward sensing capability. However, it is similarly worthwhile considering the impact of the 'Not Invented Here' (NIH) syndrome (Katz and Allen, 1982; Burcharth et al., 2014), whereby internal employees reject externally developed products or external knowledge. Therefore, overcoming this prejudice and promoting the integration of internal and external know-how becomes extremely important. A suitable means of incorporating this external knowledge into the firm's culture (Zahra and George, 2002) is through integrating processes (Ridder, 2011) such as corporate values, effective communication, and reward and incentive mechanisms (Gold et al., 2001; Teece, 2007). By doing this, individuals should feel more at ease with leveraging their own professional networks.

A central feature of open innovation is being able to tap into knowledge sources that exist outwith the firm. Like other aspects of this review, networks are considered critical to the inbound process (Chesbrough, 2003; Smart et al., 2007), hence its inclusion. Noted by Simard and West (2006), inter-organisational networks and knowledge flows have direct implications for open innovation practices. This is highlighted by Lee and Cavusgil (2006) who proposed that competitive advantage is not derived from internal capability alone, but also by the strength of a firm's network via the type and scope of relationships with others. Therefore, it is possible to see that the type of knowledge base substantially impacts innovative performance (Salavisa et al., 2012). For technology orientated firms, Asheim and Coenen (2005) and Moodysson et al. (2008) suggest that two types of knowledge base exists; analytical and synthetic. An analytical knowledge base can be characterised as one whereby firms create new knowledge in order to innovate, scientific knowledge is

significant, knowledge is largely codified, and the outcome from such knowledge bases is often radical innovation. In contrast, a synthetic knowledge base is concerned with using existing knowledge to innovate, knowledge creation through experiments and lab work is driven by the need to solve specific problems, tacit knowledge is dominant, and incremental innovation is the likely outcome (Salavisa et al., 2012).

In terms of the knowledge that exists in networks, the significance of diversity has been repeatedly indicated (Burt, 1992). Logically, if individuals within a network have very closely related knowledge backgrounds, the benefits of knowledge exchange will be greatly reduced (Nooteboom, 1999), particularly compared to a knowledge network that has individuals with varying backgrounds. From an innovation perspective, the networked model has enabled innovators to capture insights from a variety of sources inside the innovation system such as lead users (Chatterji and Fabrizio, 2013), suppliers and various other institutions (von Hippel, 1988; Brown and Eisenhardt, 1995; Szulanski, 1996).

One important ingredient within the networks is having the correct people in place to allow the necessary information to flow through the right channels. Early concepts such as champions (Schön, 1963) and promoters (Witte, 1973) firmly cemented the importance of people within the innovation process. Another early term that is frequently adopted is that of the gatekeeper (Allen and Cohen, 1969). Technological gatekeepers are those within the lab who hold key positions along the communication network, whom others often seek technical advice from, and who usually have greater contact with technical activities outside the confines of the lab (Allen and Cohen, 1969).

Whelan et al. (2011) provided an insightful perspective into how it is necessary to have the correct personnel supplied with information so that they can relay this to appropriate decision makers within the firm. The logic behind this is that if the correct communication channels are being used, the firm should have a greater chance at seeing returns from open innovation. Whelan et al. (2011) use the terms idea scouts and idea connectors to highlight this point rather effectively. In their example, they introduce two idea scouts, who act as the firms' antennae to the latest technology concepts being developed across the globe. To illustrate the importance of having a member of the network with vast internal contacts linked to individuals that can make decisions on behalf of the firm, the role of the idea connector is introduced. For open innovation to be successful, the firm is required to have appropriate processes in place to allow the idea scouts to direct their findings in a purposeful way.

A central feature of the open innovation paradigm is making use of information and technology that resides outside the business. Furthermore, the type of knowledge base that a firm connects with has a key bearing on overall performance (Salavisa et al 2012). Therefore, having the correct structure and personnel internally to sense and seize external information is paramount if that information is to be capitalised upon. Bessant and Tidd (2008) proposed that networks in familiar and unfamiliar sectors could help improve innovation.

3.4.4.3 Integrating externally seized opportunities: Transformation

Teece (2007) also proposed a third feature of dynamic capabilities – *transformational activities*. This relates to continually reconfiguring tangible and intangible assets in order to innovate, with the ultimate aim of sustained competitive advantage. This can be condensed down into the term 'continued renewal' (Teece, 2011, 1). The transformational activity aspect is related to the ability of management to effectively integrate the seized opportunity with internal operations. In comparison to the depth of content in the literature for sensing and seizing opportunities, it should be noted that there is far less for the transformation aspect of dynamic capabilities. West and Bogers (2014) noted that identifying and acquiring external sources of knowledge is only half the battle – the challenge is to fully integrate it into the firm. Due to the shortening of innovation lifecycles, a firm's competitive advantage relies on the speed at which externally acquired knowledge can be integrated and applied within internal operations (Henderson and Clark, 1990; Kogut and Zander, 1992; Powell et al., 1996). One of the obstacles associated with the integration process is concerned with organisational culture (West and Bogers, 2014). The idea of the Not Invented Here barrier has already been addressed in the seizing section. However, it is worthwhile reiterating that cultural changes are often needed when external innovations are being brought into another firm (West and Bogers, 2014). In this instance, it can be useful for firms to alter their outlook on innovation and regard the external environment as their technology base (Witzeman et al., 2006). As a result, the integration phase is a critical step in the open innovation process (Inauen and Schenker-Wicki, 2011). Crucially, for the integration step, Bititci et al. (2004) stressed that innovation through collaboration regularly requires companies to deal with strategic, operational, commercial and cultural synergies, ultimately posing additional challenges to the innovation process leading to the conclusion that collaborative innovation is highly complex and dependent upon many variables (Mendibil et al. 2013). There is also requirement for understanding open innovation as a process, and how the identified capabilities fit within an overall open innovation strategy. As already shown by Hettich (2014), open strategy models are particularly useful in helping to understand open innovation as a process.

Reflecting on the dynamic capabilities literature, it is possible to see that the subject is picking up momentum, despite the fact that there is still an aura of confusion around the concept (Perren, 2013). The work by Hine et al. (2013) is timely and a valued contribution to the dynamic capabilities literature, and hopefully their hierarchical development for capabilities can provide useful guidance for future contributions. An extension to the resource-based view, the topic of dynamic capabilities had a difficult beginning (and still has to some extent). Throughout its introductory years, there were unsatisfactory definitions, a real lack of clarity as to what constituted a dynamic capability, and almost an unwillingness to provide an example of a dynamic capability. However, now, scholars are starting to openly offer suggestions as to what a dynamic capability is. There is also greater consensus that it is important to distinguish between operational capabilities and dynamic capabilities. This is welcomed, because it separates the necessary daily routines from the higher order capabilities. Dynamic capabilities are an important feature within management

literature, which can aid towards the expansion of writings on open innovation, even if it has not been fully recognised yet, with the exception of Ridder (2011). Investigating innovation activities at a process level may help to improve understanding of open innovation.

Chapter 3. Literature review 2: Focal theory (Part II): Business processes and maturity

Driven by the thought that incorporating open innovation into firm strategy represents a fundamental step in the journey towards transforming the business, identifying, defining, modelling, and measuring key business processes provides an additional method for improving open innovation activities and performance. As a result, part II of chapter three reviews the literature on business processes and performance measurement. This part of the literature review is necessary, as it will help to answer RQ. 1 (*how do firms currently innovate in slow clock-speed sectors*), and it also assists in the evaluation of determining *the required capabilities and processes for open innovation* (RQ. 2). Moreover, business processes and organisational routines for open innovation is starting to penetrate the literature (Hutter, 2014; Wilhelm and Dolfsma, 2014). The objective of chapter three part II is to:

1. Position business processes within the context of open innovation

2. Identify multiple performance measurement tools and assess their suitability to *measure open innovation* (West et al., 2014)

3.5 Business process history

The idea of business processes was first made popular by Hammer (1990). During this period, there was a fundamental shift in management and thinking towards organisations. Traditionally, focus was directed at optimising specialist functions. However, one downfall of this structure was that it led to significant inefficiencies e.g. slow reactiveness to customer orders (Mendibil, 2003). The 1980s and 1990s marked a change in direction towards business processes. For example, Pettigrew (1992) and Van de Ven (1992) show that a process-based approach to investigating formulation, implementation, and realisation of strategies has been looked at in strategic management literature. Additionally, Jeston and Nelis (2008) and Harmon (2010) demonstrate how the role of process thinking has been incorporated into business improvement practices. Again, another area that has seen benefits from business processes is in information systems (IS). Dumas et al. (2005) argued that business processes can help facilitate specification, design, and implementation of effective IS. Moreover, popularly adopted systems such as Lean and Six Sigma make substantial use of business processes and process thinking (Clark and Fujimoto, 1991; Pande et al., 2000; Hammer, 2002; Francis and Bessant, 2005; Zu et al., 2008). All of the above has shown how the business process perspective has been beneficial to many areas. This research subsequently aims to show how business processes (Hutter, 2014; Wilhelm and Dolfsma, 2014) can be useful in the context of strategically adopting open innovation.

3.5.1 Business processes

Davenport and Short (1990) assert that a business process is 'the logical organisation of people, materials, energy, equipment and procedures into work activities designed to produce a specified end result'. In a similar vein, Hickman (1993) defines business processes as 'a logical series of dependent activities which use the resources of the organisation to create, or result in, an observable or measurable outcome, such as a product or service'. This definition by Hickman (1993) has great resonance with this thesis as the research will investigate a series of performed activities that can contribute towards the output of products and services. Bititci et al. (2011) note that the literature on business processes offers a mixture of classifications according to the purpose and function of the process. Notably, Childe et al. (1994) and CIM-OSA (1989) separate processes under the categories of support processes, operational processes, and managerial processes.

Substantial work by Bititci et al. (2011) investigated the Manage Processes adopted within firms across Europe, and they argued that it is the support and operational processes that deliver performance presently, but it is the management of those processes which sustain performance in the long-term. Childe et al. (1995) discuss operate processes as Get Order, Develop Product, Fulfil Order and Support Product. This classification does not seem to comfortably sit within the context of this research. Therefore, it is necessary to take a broader view on the classifications of business processes. This is well illustrated in the table below.

CIM-OSA (1989) and Childe et al. (1994)	Davenport (1993)	Armistead and Machin (1997)	Garvin (1998)	Porter (1985)

Operate Processes
• Get Order
• Develop Product
• Fulfil Order
• Support Product
Manage Processes
• Set Direction
• Formulate strategies
• Direct Business
Support Processes
• Support IS
• Support HR
• Support Finance
• Etc
	Operational Processes
	• Product and service development processes
	  • Research
	  • Engineering and design
	  • Manufacturing
	  • Logistics
	• Customer Facing processes
	  • Marketing
	  • Order management and sales
	  • Service processes
	Management processes
	• Strategy formulation
	• Planning and budgeting
	• Performance measurement and reporting
	• Resource allocation
	• Human resource management
	• Infrastructure building
	• Stakeholder communication
		Operational processes
		
		Managerial processes
		
		Direction setting
		
		Support processes
			Organisational
			• Work processes
			  • Operational
			  • Administrative
			• Behavioural processes
			  • Decision making
			  • Communication
			  • Learning
			• Change processes
			  • Creation
			  • Growth
			  • Transformation
			  • Decline
			Managerial
			• Direction setting
			• Negotiation and selling
			• Monitoring and control
				Primary Activities
				• Inbound logistics
				• Operations
				• Outbound logistics
				• Marketing and sales
				• Service
				Support Activities
				• Firm infrastructure
				• Human resource management
				• Technology development
				• Procurement

Table 6: Classification of business processes (Bititci et al., 2008)

As can be seen from the above classifications, there is general inconsistency as well as overlapping tendencies across the board. In contrast to the variations in classification, there is general consensus to be found on how to improve the performance of a business process. The following steps can lead to improved business process performance:

- Identify and define key business processes
- Understand these processes by documenting and modelling them
- Define metrics against these processes
- Measure and track these metrics
- Report on business fundamentals
- Benchmark where appropriate and feasible
- Take corrective action, re-design, re-configure the process to improve performance

(Armistead and Machin, 1997; Zairi, 1997; Harrington, 1998; Lee and Dale, 1998; O'Neill and Sohal, 1999; Bititci et al., 2008).

3.5.2 Measuring business performance

In an effort to understand exactly how companies in slow clock-speed industries are engaging in open innovation (RQ. 1), assessing their open innovation activity on factors such as: innovation environment, business processes, individual roles, and performance measurement provides an ability to snapshot a company's position on open innovation and assess whether or not firms are objectively adopting the model with strategic intention (Bader and Enkel, 2014).

In order for management to make informed decisions, there needs to be mechanisms in place that allow them to assess the level of performance within a given business unit or project team. One way of contributing to this is to make use of tools that can assist in measuring current performance of specific processes. In terms of operations and process management, Slack et al. (2006) noted that performance improvement is the ultimate goal. Measuring performance of processes allows management to appreciate current performance levels, which in turn allows them to see how wide or narrow the gap is until desired performance can be achieved (Slack et al., 2006). As highlighted by Francis and Bessant (2005), there is considerable scope for improving existing operating processes, simply by eliminating various forms of waste so that higher performance can be achieved. Therefore, this thesis aims to translate these sentiments into the context of open innovation so that firms can professionalise their activities (Gassmann et al., 2010).

Given that innovation is regarded as a key factor towards achieving competitive advantage (Söderquist and Godener, 2004), measuring activities concerned with innovation is necessary (Dewangan and Godse, 2014). Although, caution should be aired, as this is by no means a straightforward task (Bititci et al., 2012; Costa et al., 2014) due to the fact that R&D activities are often intangible and uncertain, and thus difficult to measure (Bhasin, 2008; Enkel et al., 2011). In addition, Loch and Staffan Tapper (2002) mentioned that is it sometimes only possible to assess the success of an innovation as a reflection exercise, although this would not be the case if the firm was promoting a managed process. As noted by Hagedoorn and Cloodt (2003), there is no recognised formula for measuring innovation performance. Accordingly, they support a multi-indicator approach e.g. measuring R&D expenditure, patent counts, patent citations, and new product announcements. Other metrics may include profitability, market share, and market growth (Wang and Lin, 2012) (see Agarwal et al. (2003); Joshi and Sharma (2004); Rijsdijk et al. (2011). This multi-perspective approach clearly has its merits.

As indicated by Chenhall and Langfield-Smith (2007), measuring performance is extremely important for managers who are interested in monitoring the activities of a company, as this allows for more effective planning and control of certain processes (Neely et al., 2005; Rey-Marston and Neely, 2010). Although, deciding what areas of innovation to measure can be a difficult task (Neely et al., 1996). An extensive literature review has revealed the most pertinent areas to measure for inbound open innovation. Notably, as shown by Enkel et al. (2011), measuring the level of maturity is one option that allows managers to assess their current innovation practices.

3.6 Maturity models

3.6.5 Software Capability Maturity Model (CMM)

Interest in maturity models has steadily increased over the past decade (Wendler, 2012) as they have been recognised as an important improvement tool for organisations (Van Looy et al., 2013). Originally conceived in the software industry, maturity model use has penetrated into other domains such as R&D (Berg et al., 2006), project management (Hillson, 2003), risk management (Sharp et al., 2002; Strutt et al., 2006), innovation (Essman, 2009), and even open innovation (Enkel et al., 2011). However, on the whole, they have been predominately applied in a software development/engineering capacity, as highlighted in Wendler (2012). In order to explain what they are and how their application can be useful in the context of inbound open innovation, this section will begin by using the model developed by Paulk et al. (1993); Paulk et al. (1995) to provide an illustration.

Although the term maturity is used, this is perhaps not the best word to describe levels of performance. The purpose of the model is not to suggest that a firm is either mature or immature. Instead, the term mature refers to having effective practices, procedures and systems, whereas an immature level reflects inefficiency and poor practice. The maturity model developed by Paulk et al. (1993) shows five maturity levels: initial, repeatable, defined, managed, and optimising. The idea is that the firm

can improve their performance through continuous process improvement based on many small, evolutionary steps, as opposed to giant revolutionary innovations (Paulk et al., 1993). The diagram below provides a clear visual representation of such a model.

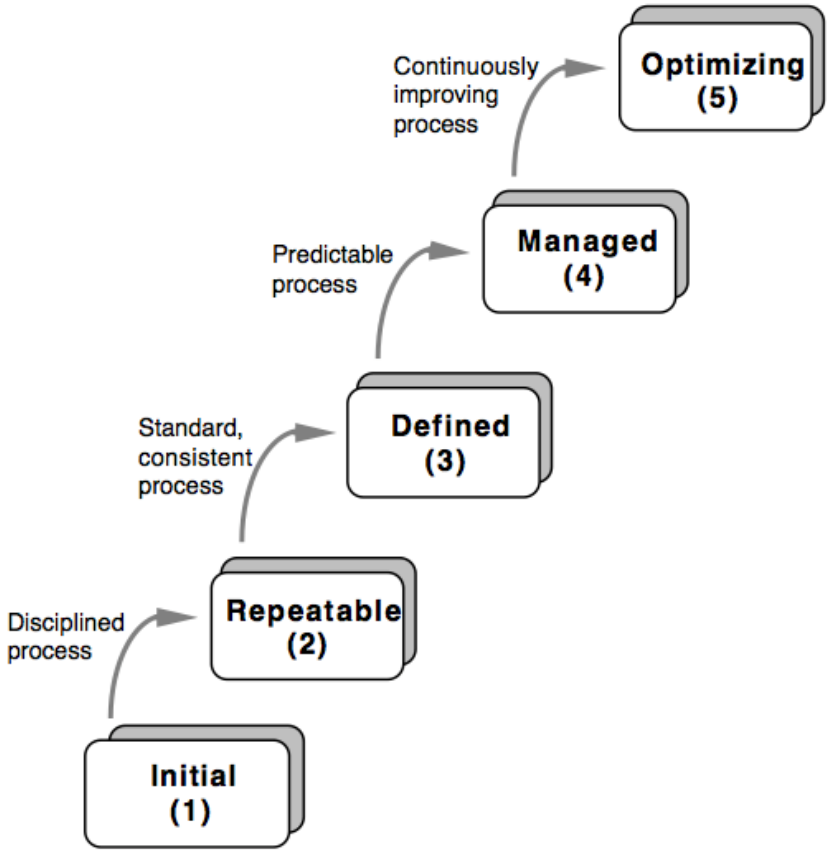


Figure 12: 5 level maturity model

(Paulk et al., 1993)

Level 1 (**initial**)

- The firm does not have a stable environment for software development
- Crises are frequent
- Success depends on the heroics of select individuals

Level 2 (**repeatable**)

- Policies for managing projects are established
- Management of new projects is based on prior experience of managing similar projects
- Project commitments are based on the outcomes of previous projects

Level 3 (**defined**)

- Processes for developing and maintaining software are documented for the entire firm
- Processes can be changed as required to help employees perform more effectively
- Processes are well defined (readiness criteria, inputs, standards, procedures, verification mechanisms, outputs, and completion criteria)
- Software engineering and management activities are stable and repeatable

Level 4 (**managed**)

- Measurement of quality for products through quantitative measures
- Productivity and quality important aspects for measurement
- Data on processes is collected and analysed

Level 5 (**optimising**)

- Whole firm is focused on continuous process improvement
- Strengths and weaknesses in processes are identified
- Cost-benefit analyses are performed
- Route causes of defects are investigated
- Lessons learned are communicated
- Waste reduction priority (Paulk et al., 1993)

As mentioned at the beginning of this section, several maturity models exist. Therefore, it is felt that it would be appropriate to conduct a comparative analysis of them once they have all been addressed. The discussion now continues towards the Project Management Maturity Model.

3.6.6 Project Management Maturity Model (ProMMM)

The ProMMM was developed with a number of key objectives in mind. First, firms wanted a means for finding out if the current project management practices were adequate within their organisation. In addition to this, the ProMMM would provide them with the opportunity to compare themselves against competitors (Hillson, 2003). As noted by Hillson (2003), the ProMMM draws on multiple maturity models for its structure e.g. the Software Capability Maturity Model by Paulk et al. (1993); Paulk et al. (1995), the EFQM Excellence Model (EFQM, 1999), and the Risk Maturity Model (Hillson, 1999). The ProMMM's structure is as follows:

ProMMM Level 1 – the **Naïve** project management organisation

- The value of using projects to deliver business benefits is not understood
- Unstructured approach to project management (no processes)
- Minimal or no attempt to learn from previous experiences
- Management processes are repetitive
- Firm is resistant to change (culture)

ProMMM Level 2 – the **Novice** project management organisation

- Experimentation with project management (not everyone is convinced of the benefits – culture)
- No formal or structured processes in place (processes are ad-hoc)
- Project management is not effectively implemented
- Full benefits are not accrued

ProMMM Level 3 – the **Normalised** project management organisation

- Project management is implemented throughout the firm
- Processes are formalised and widespread (staff have been trained and have experience)
- Employees understand the benefits of project management (culture)
- Benefits might not be fully achieved everywhere

ProMMM Level 4 – the **Natural** project management organisation

- Project-based culture within the firm
- The firm adopts a best practice approach to project management
- Project information is used to improve operating processes in an effort to achieve competitive advantage
  (Hillson, 2003)

3.6.7 Open Innovation Maturity Model (OIMM)

Having noticed that Enkel et al. (2011) developed a maturity model in the context of open innovation, their work shows support for its use. Their model is developed based on a student's Master thesis from Radbound University Nijmegen. The framework is separated into three main areas, namely: climate for innovation, partnership capacity, and internal processes. To begin, Enkel et al. (2011) developed a preliminary framework for open innovation maturity. However, it was only until they ran workshops with innovation managers that the model grew additional content. The maturity model for open innovation adopts the same maturity scale as Paulk et al. (1993) i.e. initial, repeatable, defined, managed, and optimising. As an illustration, the scale below provides an insight into the 'climate for innovation' section of the model. However, for a comprehensive account see Enkel et al. (2011) for information on 'partnership capacity' and 'internal processes'.

Climate for innovation

1. **Initial**
   - Limited initiative taking
   - Accidental opportunity identification

2. **Repeatable**
    - Success sharing (informal)
    - Informal assessment
    - Impulse screening
3. **Defined**
    - Documented open innovation strategy
    - Managerial success story sharing
    - Introduction of champions
    - Champions screen opportunities
4. **Managed**
    - Open innovation strategy encouraged by management
    - Open innovation targets set
    - Encouraged initiative taking
    - Scouts assigned
5. **Optimising**
    - Firm-wide initiative taking
    - Management 'walking the walk'
    - Focus on external opportunities
    - Open innovation assessment

To reiterate, there is also maturity content for both partnership capacity and internal processes. The table below reviews the benefits and disadvantages associated with the existing open innovation maturity model.

Enkel et al. (2011) open innovation maturity model	
Theoretical advantages	**Theoretical disadvantages**
• First published works on open innovation maturity • The framework of 'partnership capacity', 'climate for innovation', and 'internal processes' is based on theoretical underpinnings • The framework builds on existing maturity models e.g. Paulk et al. (1993) • Helps to address the gap in research concerned with measuring open innovation • Provides evidence that firms have varying levels of open innovation maturity	• The content of the framework is largely based on interviews and workshops with Innovation Managers, as opposed to being developed solely from theory and then tested in industry • The paper mentions that an additional literature review was undertaken, but the literature review is not present in the paper • It was difficult for companies to identify excellence in open innovation • Limited quotations from managers participating in the study • Spin-offs and location decisions are omitted from the model
Practical advantages	**Practical disadvantages**
• Provides firms with the ability to measure open innovation	• Without understanding of the questions asked in the maturity

performance • Data collected from a cross-section of industries (healthcare, consumer lifestyle and lighting, telecommunications, and food) • An Excel tool was developed to help measure excellence in open innovation, giving practical benefits to managers by visually communicating open innovation maturity • Possibility for evaluating individual business units/teams or whole organisations • Extensive inclusion of a variety of factors for maturity assessment	assessment, there is risk that this will provide a misrepresentation of the team/company • Potential for over-estimating maturity rating e.g. from defined to managed levels.

Table 7: Review of open innovation maturity model by Enkel et al. (2011)

3.6.8 Strathclyde Institute for Operations Management (SIOM) Maturity Model

After becoming acquainted with additional material from the Manage Processes study undertaken by the Strathclyde Institute for Operations Management (2008), it was found that they had adopted a 3 level maturity assessment (basic, intermediate, and advanced). Their maturity assessment was based on 40 key areas related to the Manage Processes. A selection includes: check financial performance, check KPIs, check staff performance, communicate change, communicate company performance, and monitor macro environment. However, the SIOM maturity table was selected here due to its structure and layout. The framework enables users to not only rank whether a given activity is 'basic', 'intermediate', or 'advanced', but they can also assign a numerical value to that maturity rating, thus offering more objectivity. Consequently, this gives greater accuracy as opposed to the other maturity models listed above.

Activity	**Basic**			**Intermediate**			**Advanced**		
Score	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]

Table 8: SIOM maturity framework

3.6.8.1 Comparative evaluation of maturity models

Due to the volume of maturity models that exist in the literature, it is sensible to make a note of their relative strengths and weaknesses so that a fair evaluation can take place. First, the strengths of the CMM by Paulk et al. (1993) are that it takes a rational approach to the naming of each maturity level. This is in contrast to the ProMMM whereby they have chosen to adopt a recurring 'n' theme to denote each level. The naming of the levels in CMM is intuitive and it is recognisable that each

name in the model is at an advanced state to its predecessor; the ProMMM naming seems clumsy. Furthermore, the core content of the CMM is helpful in the fact that each level has distinguishing features that researchers should recognise as being the advancing element from the previous level. Researchers will then be able to take the core elements of each level and replicate this with their own desired content (e.g. open innovation literature). Having said that, weaknesses do exist for the CMM in the context of this research. For example, empirical data will be collected through a number of workshops and interviews with various companies. Therefore, it is felt that the CMM has too many maturity levels for a workshop setting, as it would take up valuable time explaining what each level meant. In addition, it might be confusing for workshop participants to distinguish one level from another.

The strengths of the ProMMM are that is takes inspiration from previous maturity models for its structure. The model also uses a questionnaire, thus allowing firms to diagnose their current position. The weaknesses however, are that its content is generally thin, and there is not much evidence to suggest that the model has been developed from theory. The Open Innovation Maturity Model (OIMM) by Enkel et al. (2011) on the other hand started off by reading the literature. The strength of the OIMM is that it focuses on open innovation as a whole i.e. looking at both inbound and outbound activities. Yet, because the OIMM model does not seem to use a full range of open innovation literature, and the fact that it was developed in unison with innovation industry professionals, this could be seen both positively and negatively. For instance, if a greater amount of open innovation literature was used, Enkel et al. (2011) could have validated the literature against industry practice. However, by incorporating the views of industry professionals, it gives an insight into what is happening in practice. Another positive of the OIMM approach is that they used a questionnaire to conduct an open innovation assessment. Similar to the ProMM, the OIMM can be used to diagnose a company at large. Also, despite the fact that Enkel et al. (2011) focus on three areas related to open innovation (climate for innovation, partnership capacity, and internal processes), it is felt that the dynamic capabilities framework (sensing, seizing, and transforming) (Teece, 2007) is more suited to investigating open innovation because these are core activities required to be performed by the company when engaging in open innovation.

Finally, the SIOM maturity model has its benefits in the fact that the template adds objectivity to the assessment (more objective than other models). Moreover, the model is simple and thus understandable; there is minimal requirement to explain what each maturity level means compared to the levels in Paulk et al. (1993) and Hillson (2003) maturity models. Also, due to its structure, it is possible to transfer the necessary theory of subjects into each maturity level. If one were to discuss weaknesses, it would be that its content is limited, and that inspiration must be taken from other maturity models to fully develop the model. However, this is actually seen as an advantage, as it gives the user power to make self-judgements.

3.8 Conclusions

The purpose of this chapter was to set out the focal theory for this research. Following on from the theoretical shortcoming identified in chapter 1 (i.e. (1) *how to become better at open innovation, and* (2) *the lack of knowledge surrounding the processes involved and performed by firms using the inbound system*), this chapter was grounded in dynamic capabilities (Teece, 2007) because it offers a suitable framework in which to study open innovation. By doing so, it makes it possible to investigate the current maturity levels for three fundamental open innovation activities. The table below summarises the main theoretical contributions of each stream of literature.

Process of innovation	Dynamic capabilities	Search activities
• Trend towards non-linear methods for innovating • Radical innovations require firms to seek out, tolerate and experiment • Establish effective external links • Willingness to take on external ideas • Effective champions and a strong orientation towards R&D	• Sense opportunities and threats • Seize opportunities (assimilate and integrate knowledge) • Transformational activities (continually reconfigure tangible and intangible assets)	• Search diverse sources of knowledge • Internal searching depth and scope • External searching breadth and depth • Too much searching is counter productive
Firm openness	**Absorptive capacity**	**Networks**
• Varying levels of openness • Exploration vs exploitation strategy • Openness capability	• Conducting R&D enables firms to recognise the value of new information, relay it across the organisation, and apply it in a commercial manner	• Strength of a network is derived from the type and scope of relationships within • Significance of diversity • Champions, promoters, and gatekeepers • Idea scouts and idea connectors

Table 9: Key areas applicable to inbound open innovation

Moreover, the aim of this chapter has been to link the identified issues in chapter 1 to the appropriate literature, with the ultimate goal of providing the necessary theoretical foundations for the next stage of research – data collection. At the present moment, there is need for further research into the capabilities required for inbound open innovation. In addition, there is a lack of attention paid to the specific processes

involved during the inbound process. Hence, the data collection stage will focus on measuring current open innovation performance so that an assessment can be made regarding the extent of open innovation management and organisational transformation. The forthcoming chapter discusses the chosen research questions and methodological issues relevant to this research.

Chapter 4. Research methodology

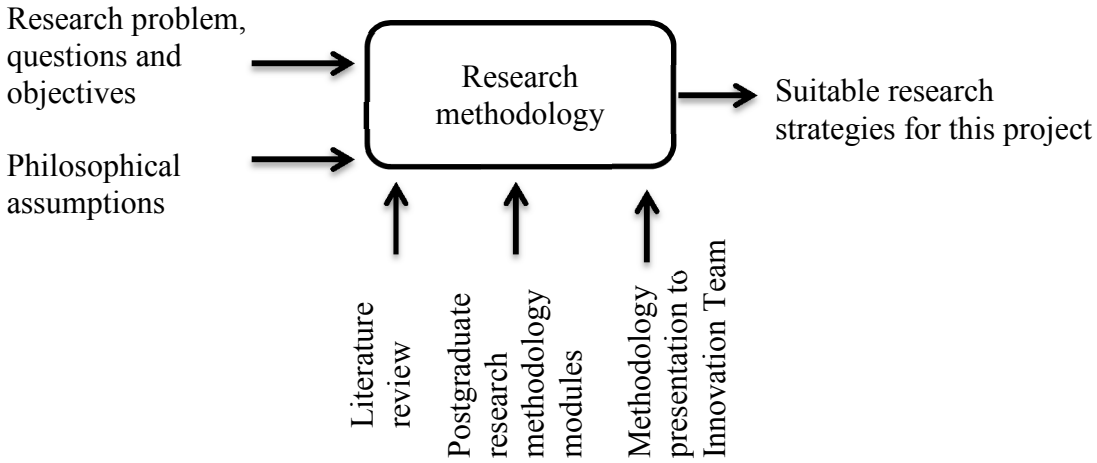


Figure 13: Chapter 4 input - output diagram

4.1 Introduction

The main aim of this chapter is to demonstrate an appropriate research methodology for investigating the research questions. In order to do this, this chapter will review the various options available for researchers of business and management studies, and provide an argument to help support the selected research methodology. To begin, it is first necessary to make explicit the various terms associated with research methodology, as this will help increase clarity about what is being discussed. In addition, as the development of new knowledge is one of the main outcomes in PhD research, research philosophy becomes an integral part of that process. This chapter will provide a critical review of various philosophies that can be adopted for conducting research, and will conclude by discussing the chosen research paradigm and strategies for this specific project. The figure below illustrates the research process of this study, providing a visual representation of the links between research questions, actions performed, and research outputs throughout various stages of the research.

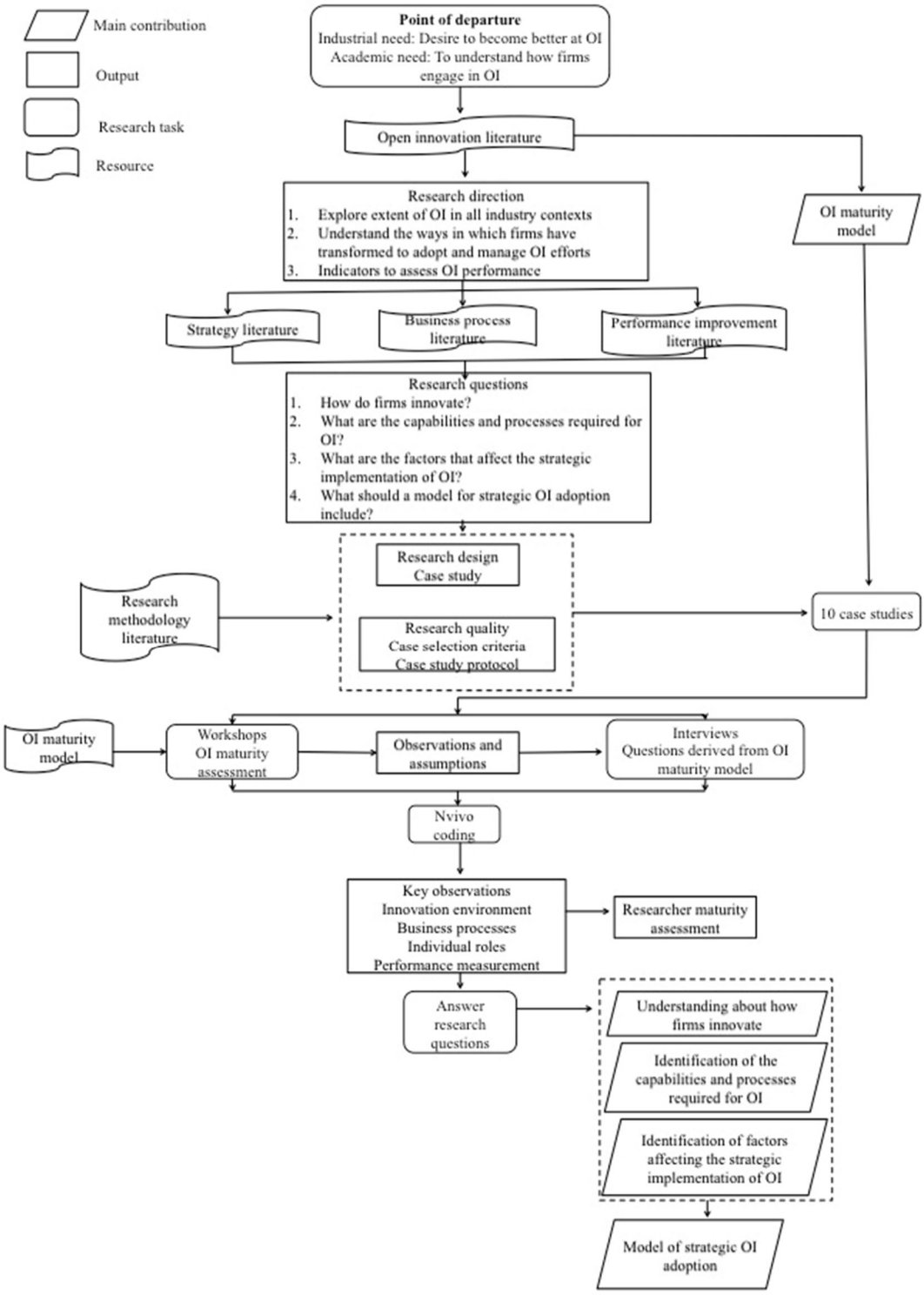


Figure 14: Research process summary

4.2 Making sense of the terminology

A useful starting point would be to clarify what the term *research methodology* means. According to Hussey and Hussey (1997, 54), '*methodology* refers to the overall approach to the research process, from theoretical underpinning to the collection and analysis of data.' Silverman (1994, quoted in Hussey and Hussey, 1997: 54) stated that, 'like theories, methodologies cannot be true or false, only more or less useful.'

Another important aspect to address at this point is that of *research approach*. Saunders et al. (2009) make it clear that research approaches are characterised by being classified into separate dichotomies. They acknowledge that this involves the researcher deciding between a deductive or inductive approach. To explain, deduction lends itself to developing a theory and hypotheses, and testing those hypotheses. Conversely, induction involves gathering data in order to develop theory. Therefore, deduction is much more concerned with theory testing, while induction is more focused towards theory building.

Thirdly, for clarification purposes, a *research strategy* is merely a vehicle enabling the researcher to answer his/her research questions. Examples of research strategies include: experiments, surveys, case studies, and ethnography (Saunders et al., 2009). Furthermore, *research methods* relate to the investigative tools used in order to help answer the research questions. Methods include questionnaires, interviews, and observations. Finally, and although not immediately important, a *research design* is essentially a detailed plan that will be used to guide and focus the project (Hussey and Hussey, 1997). This can involve providing support for conducting research in a particular company or department, and why certain individuals have been interviewed as opposed to others.

4.3 Research aim and questions

As already identified in chapter one, the aim of this thesis was to:

> **Understand how the velocity of change in the external business environment impacts firms' strategic open innovation orientation.**

This research aim was designed to explore how firms engage in open innovation so that it is possible to understand how firms can become better at open innovation. The research aim is influenced by the gap in knowledge surrounding (1) the processes involved in inbound open innovation (Enkel et al., 2009), (2) the lack of options for measuring open innovation performance (Enkel et al., 2011), and (3) the desire of companies to professionalise open innovation internally (Gassmann et al., 2010). Moreover, due to the identified similarity between open innovation and dynamic capabilities (Ridder, 2011), there is an opportunity to test this framework in an open innovation context (MacKinven et al., 2013). By exploring the results of the

literature review in chapter two, multiple research questions arose as being worthy of further inquiry. To reiterate, these research questions are listed below:

RQ. 1 *How do firms currently innovate in slow clock-speed sectors?*
As the investigation is trying to find out what good open innovation looks like, the first task is to find out how the case study firms currently innovate. Using the maturity assessment tool can help assess the current state of open innovation maturity. Chesbrough (2003) proposed that companies were choosing different pathways for commercialising their technology. However, innovation literature published pre Chesbrough (2003) already referenced a more collaborative approach to working, recognising external knowledge as being important to a firm (Rothwell, 1992; Tidd et al., 2001). Therefore, there is a requirement to assess to what extent companies have implemented open innovation.

RQ. 2 *What are the capabilities and processes required for open innovation?*
By analysing the gathered data, it will be possible to gain an appreciation for the capabilities and processes necessary for firms to benefit from open innovation. This research question was developed through a gap in knowledge expressed by Wilden et al. (2013) who recognised that research efforts have failed to investigate the capabilities and processes associated with internal structures and the external environment. Moreover, Hutter (2014) recently provided support for research into capabilities for open innovation.

RQ. 3 *What are the factors that affect the strategic implementation of OI?*
Firms want to improve their open innovation activities to a professional level (Gassmann et al., 2010), however limited research has looked at the challenges associated with pursuing OI (Hutter 2014). Through understanding how firms perform certain open innovation activities, it will be possible to appreciate what factors are most important to implementing open innovation from a strategic point of view. The literature already recognises the NIH Syndrome as being a barrier to open innovation (Katz and Allen, 1982). However, strategy and open innovation is only beginning to be explored, therefore work is sought to uncover issues that could impact on OI being introduced into a firm's strategy.

RQ. 4 *What should a model for strategic OI adoption include?*
This question brings the research full circle by offering a theoretical insight into what a strategic open innovation model would look like. Overall, this links back to the idea of professionalising open innovation (Gassmann et al., 2010). At the moment, research shows a trend towards open strategy making (Chesbrough and Appleyard, 2007; Whittington et al., 2011). However, few have attempted to model open innovation as an integrated system. This theoretical proposition represents a starting point for future research. Moreover, this model seeks to address an industrial problem; whereby the idea of open innovation is only partly understood, and more insight is sought before firms will commit additional resource to exploring it in more detail.

By answering these research questions, it will be possible to understand how open innovation is performed in practice. In turn, by analysing the gathered data, there will

be opportunity to further develop the literature and comment on the use of open innovation as strategy.

4.4 Research philosophy

Similar to the above, there is particular terminology used when discussing research philosophy. When studying research philosophy for the first time, some researchers may feel completely overwhelmed. Not only does research philosophy challenge the researcher in the sense of being subjected to a wealth of new terminology, but it also forces the researcher to think about their own philosophical assumptions. Here, the discussion begins by introducing what a research paradigm is, and how understanding it is a crucial step in selecting an appropriate research design for the research questions set. Once this is done, the two main traditions of philosophical research, positivism and interpretivism are presented. Following this, potential research strategies will be outlined before finally revealing what philosophical position and research strategy this research has adopted.

The research paradigm is a fundamental ingredient within any thesis. To provide background to the paradigm, Kuhn argued that the scientific disciplines (mathematics, astronomy, physics) started off in in a pre paradigmatic state. In order to produce theory, scientists had to build their results from the absolute basics, and their only foundation on which to do so was through philosophy. Until a discipline becomes mature, only then will a paradigm form around it (Dörfler, 2005). Of crucial importance is that, once a paradigm is formed, it determines what must be taken for granted (Kuhn, ibid p.37). When a scientist is working within a discipline, he/she is bound by the paradigm in which they are working, that is until a superior one comes along and dislodges the old one in favour of the new one. For example, when Einstein showed that nothing is able to travel faster than the speed of light, Newton's law was replaced by Einstein's theory of general relativity. Therefore, all scientists within this discipline must now adhere to Einstein's theory, not Newton's. In terms of the paradigm, Dörfler (2005, 11) suggested it is 'the window through which one sees the world'. Consequently, the paradigm has influence over the methodological approach to research. This is because, certain philosophical positions better lend themselves to certain methodologies than others.

The researcher undertaking this study sees the world with an appreciation for science, as scientific discoveries are able to enhance the lives of human society. The researcher also believes that science can help us to better understand research problems, but concedes that holding a rigid positivistic view has its limitations because it claims that knowledge is objective or value free (Easterby-Smith et al., 1991). A controlled environment clearly has its benefits in medical research and engineering. However, in the social sciences, one cannot be so narrow. A positivist worldview works in certain situations where it is necessary to understand the cause and effect of forces working on one another. For example, knowing the pressure fatigue level of a metal component is obviously vital when designing new products for subsea or aerospace applications (Parkes et al., 2012). Yet, if one were to suggest that solely running a patent count would provide a true representation of a firm's

innovation performance – this would not be accurate (Dewangan and Godse, 2014). Therefore, adopting a multi-perspective view can provide a more rounded interpretation of reality, and that it would be naive to adamantly favour one outlook over another.

The paradigm encompasses four terms (axiology, epistemology, ontology, and methodology). *Axiology* is concerned with ethics and the part they play in the researcher's own research process. Saunders et al. (2009) argue that self held values are an important part of the process if results are to be credible. Furthermore, they propose that adopting a particular philosophical approach is a reflection of the researcher's own values, as is the choice of data collection techniques. For instance, if the researcher chooses interviews as a data collection method, it could be said that they place greater importance on the act of human interaction as opposed to collecting anonymous survey responses. Similarly, if the researcher chooses a combined approach of interviews and quantitative data collection, the researcher has an appreciation for the results that can be derived by adopting both methods.

Epistemology is a component of philosophy related to knowledge, and what is considered to be valid knowledge (Hussey and Hussey, 1997). The question asked here is, what is the relationship of the researcher to that of the researched? To paraphrase Easterby-Smith et al. (1991), epistemology is a general set of assumptions about the best ways of conducting research in a particular setting e.g. in an organisation. Lastly, ontological assumptions must be addressed. When discussing *ontology*, Creswell (1994) refers to assumptions about the nature of reality as being either quantitative (positivistic) or qualitative (phenomenological). This means that the researcher must decide whether or not they believe reality exists objectively, and is external to the researcher, or reality is subjective and socially constructed. As a suitable point of departure, focus will now be directed towards why having an understanding of philosophy is important for researchers. Moreover, this also signals an opportunity to introduce the main philosophical paradigms.

Researchers that have a knowledge and understanding about the various philosophical paradigms, can make greater informed decisions about what paradigm best suits their research questions. Easterby-Smith et al. (1991) provide three reasons as to why it is necessary for researchers to have more than just an awareness about philosophy, and these are identified below:

1. Research designs can be clarified

2. Enables the researcher to understand why certain designs will work and why others will not

3. Allows the researcher to identify and construct research designs outwith his/her past experience

4.4.1 Philosophical schools of thought

A central feature of a PhD thesis is concerned with entering the field with a particular philosophical worldview. Therefore, this section serves the purpose of informing on a number of world perspectives prior to collecting data. When introducing paradigms, scholars generally describe them by means of looking at a spectrum. In the time of Galileo, dominant ideas about nature were predominately derived through the Church or Aristotle. The only way in which to escape this restrictive barrier towards thinking at this time, and to remain culturally sensitive was to concentrate on the examination of things that could be quantifiably measured. Examining weights, sizes, and temperatures were not deemed offensive, as they were considered irrefutable. In this sense, natural scientists gather information about reality through experimentation. Also, due to its successful nature in obtaining results, this approach was adopted by social scientists towards the end of the nineteenth century. This approach to research is synonymous with the positivistic philosophy, a term introduced by Compte (1853). The positivistic paradigm can therefore be thought of as one of the polar ends of the spectrum.

Despite philosophies having certain characteristics, which may make the researcher feel like they are being put into a box, it is somewhat comforting to know that Easterby-Smith et al. (1991) mentioned that it would be extremely difficult to find any philosopher in the world who succumbed to all the beliefs that encompass a single philosophy. Therefore, the following text will discuss each philosophy from its purest perspective, albeit realising that total agreement may be somewhat improbable. However, on the whole, individuals that hold a positivist mind-set have an ontological belief that reality is objective and external to the individual. In addition, they believe that the sole purpose of research is to predict and control nature. From an epistemological view, such researchers believe in absolute objectivity (Guba and Lincoln, 2005).

In terms of methodology, positivists will generally focus on the development and testing of hypotheses. Merriam (1991) also mentioned that replication is an important aspect of positivism. For example, positivists will value results that can be predicted i.e. an experiment that can be conducted multiple times over and the same results will occur. Typically, positivism and quantitative methods are thought of as partners. As positivists believe there is only one truth (Lincoln et al., 2011), research often makes use of large samples (Easterby-Smith et al., 1991), and quantitative analysis because, positivists think this will provide the truth – whatever truth is.

Furthermore, the positivistic researcher's axiological standpoint is that research should be conducted in a value-free way, whereby the scientist remains independent of the data (Saunders et al., 2009). Finally, because positivism is largely associated with quantitative methods (but not exclusively), researchers adopting this paradigm are said to be working deductively. This means that, upon using existing theories, the researcher will develop a series of hypotheses that will be subject to empirical scrutiny (Bryman, 2004). When scientists at CERN conducted an experiment that showed, what they believed to be neutrino particles travelling faster than the speed of light, at measurements of high significance within the errors, there was rightly a need

for such results to be checked (Cox, 2011). After checking, the results have been falsified (Wolchover, 2012). However, if proven to be correct, this would have been one of the most profound discoveries over the past 100 years in physics, and would have required a complete re-write of our understanding of the universe (Cox, 2011).

At the other end of the spectrum lies interpretivism, which is often linked back to the thoughts of Max Weber (1864-1920). Interpretivism is the philosophy that is largely associated with having an ontological view that understanding should be generated through the interpretation of subject perceptions (Lincoln et al., 2011). Therefore, the presumption is that reality is not objective and external, but socially constructed and thus subjective (Easterby-Smith et al., 1991). Epistemologically, interpretivists believe in studying the details of a situation so that they can better understand the reason behind certain actions taking place (Habermans, 1970). In order to do this, data collection predominately involves small samples, in-depth investigations, and are therefore typically qualitative in nature (Saunders et al., 2009). Consequently, researchers adopting an interpretivist standpoint place value in being part of what is being researched.

A potentially confusing aspect of reading about interpretivism is that authors tend to discuss interpretivism under different guises. However, as pointed out by Hughes (2006), phenomenology, hermeneutics, and social constructionism are simply variants of interpretivism. Konstantinos (2009) relieved the confusion by asserting that they all share the same common belief that an interrelationship exists between the researcher and that of the researched. As an interjection, phenomenological research seeks to describe human activities and experiences as opposed to explain them (Denzin and Lincoln, 2000). Furthermore, as a research paradigm, phenomenology is associated with the inductive approach to research. Therefore, it is possible to see how interpretivism and positivism are treated as polar opposites to one another. A brief summary of the two philosophies is provided in the table below.

	Positivism	Interpretivism
Ontology: The researcher's view of how reality exists	There is a single truth that can be measured (Guba and Lincoln, 2005). The world is external and objective (Easterby-Smith et al., 1991)	Socially constructed with multiple realities (Denscombe, 2007) Meanings are subjective (Saunders et al., 2009)
Epistemology: The best way of conducing research in a particular setting	No contact should be made with what is being researched (Merriam, 1991; Guba and Lincoln, 2005)	Researchers are part of the social world that they are investigating (Guba, 1990; Denscombe, 2007)
Methods: The tools used to help answer the research question(s)	Quantitative Questionnaires, lab experiments, mathematical modelling	Qualitative Interviews, ethnography, case studies, action research
Axiology: Values that researchers hold towards research	Research should be taken in a value free way, whereby the researcher remains independent of the research subject (Saunders et al., 2009)	The researcher is part of what is being researched therefore findings will be subjective (Saunders et al., 2009)

Table 10: Comparison of research philosophies

4.4.2 Philosophical position of this research

The first research question: *how do firms currently innovate?* suggests that some degree of questioning is required. Indeed, questions will be asked to informants about how they engage in certain activities, but this research goes further by also asking them to undertake an assessment of how they perceive to perform each activity after describing how they do those activities. Therefore, this part of the investigation requires both qualitative and numerical data collection. What is evident in this research is that there has been no hesitation to work with variations in epistemology, ontology or axiology. In line with Tashakkori and Teddlie (1998), the adopted standpoint is that the subject matter should be studied in ways that are deemed appropriate, and this is what has been done.

The outlook of this study believes that choosing between philosophical positions is rather unrealistic in practice, and that one epistemology, ontology or axiology may be more appropriate for answering certain research questions. Generally, if one were to measure performance of a certain activity, there would be an inclination to use some form of numerical analysis. This is true to an extent. However, because there is currently no agreed upon means of measuring open innovation performance via

calculation, other mechanisms are required. Therefore, this research places an importance on subjective perceptions by asking project teams to rate their team's current level of open innovation performance based on content derived from the literature and assign a numerical value to convey their performance level. Consequently, the ontological viewpoint for this specific question would be directed towards objectivity.

In contrast, for RQ.2: *What are the capabilities and processes required for open innovation?* - the focus is on determining what is required of companies to benefit from open innovation. As a result, this lends itself to being much more qualitatively orientated and thus subjective. Through process map development and participant description of the processes, the intention is to obtain a thorough understanding through group participation. It is felt that this method can best achieve answers for the question set. Moreover, the process mapping technique is supported by Francis and Bessant (2005), not only as a method for identifying waste, but also as a basis for starting performance improvement initiatives. Conversely, answers to RQ.3 will be derived through interpretative analysis, in light of the findings from RQ.1 and RQ2. To answer RQ.4, both gathered data from interviews and workshops, as well as academic literature will be used to develop a model of strategic open innovation adoption.

For the purposes of being explicit, this research adopts the pragmatic research philosophy. A Pragmatist believes that one of the most important parts to research is selecting the appropriate data collection technique for answering the respective research question (Creswell, 2009). In that regard, it is hoped that this sentiment has been reflected in the aforementioned paragraphs. Moreover, as noted by Denscombe (2007), the pragmatic philosophical position is generally accepted to accompany a mixed methods approach, of which will be discussed in the forthcoming chapter.

4.5 Conclusions

One of the intentions of this chapter was to express the philosophical standing of this thesis. As part of the learning process around research philosophy, it was necessary to become familiar with the different forms of philosophical positions as well as their associated terminology. The first part of this chapter introduced these terminologies and their meaning before reaffirming the research questions at the centre of this investigation. Subsequently, dominant research philosophies were discussed in order to appreciate the spectrum of worldviews. Naturally, the philosophical beliefs of researchers reflect the way in which they see the world, ultimately impacting on how research questions will be tackled. By considering ontological and epistemological assumptions, the philosophical position of this study rests within pragmatism, a view that positions the research questions ahead of methods or research philosophy. The following chapter will explore, in detail, the research design for this study.

Chapter 5. Research design

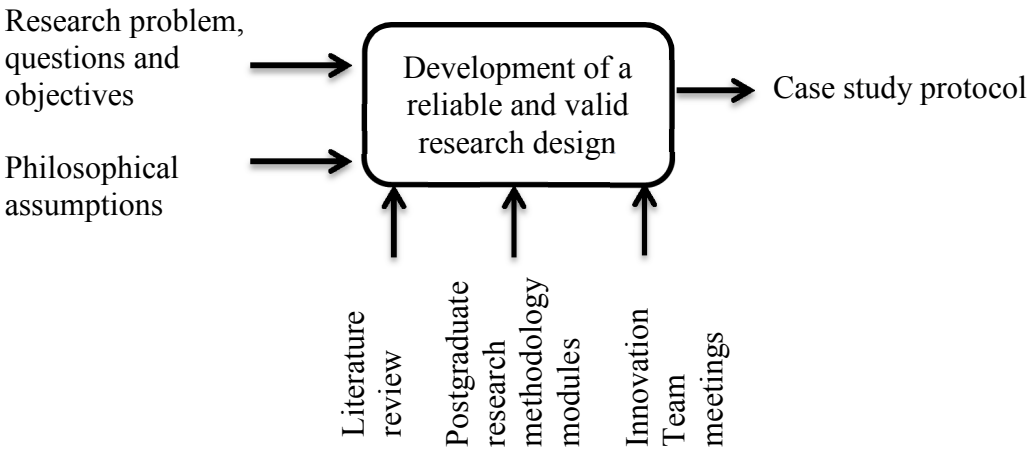


Figure 15: Chapter 5 input - output diagram

5.1 Introduction

This chapter addresses the matter of research design specific to this thesis. In doing so, attention is given to theory on case study design, as this is the chosen research strategy. Additionally, various data collection and analytical instruments are discussed before identifying the ones adopted for this research. Details are also given about the cases used in this study. Finally, the chapter concludes by tackling research quality. To do this, a definition of research quality is provided that will subsequently be used as a benchmark to ensure that this research meets the required quality standards.

5.2 Understanding the research design

According to Creswell (2009, 233), 'research designs are plans and procedures for research that span the decision from broad assumptions to detailed methods of data collection and analysis. It involves the intersection of philosophical assumptions, strategies of inquiry, and specific methods.' Yin (2003, 20) suggests that the research design is 'the logical sequence that connects the empirical data to a study's initial research questions and, ultimately, to its conclusions.' Clearly, the research design is much more than a plan for research. In fact, some regard it as a blueprint for research - from (1) what questions to ask, (2) what data is relevant, (3) what data should be collected, and (4) how to analyse such results (Philliber et al., 1980). Ideally, the research design should help to avoid the unfortunate situation whereby the gathered data does not help to answer the research questions.

5.3 Research stages

At this point, it is worthwhile to highlight the stages performed in this research. This brief section will address the initial understanding of open innovation, theory building and testing, as well as evaluating the research.

The *pre-understanding stage* involved an initial proposal for research. Prior to accepting the research scholarship, there had been no previous academic encounters with the term open innovation. Initial discussions with supervisors and reading of the literature became a very liberating and creative process, which ultimately resulted in keeping a log of potential research opportunities. In addition to this, there was attendance The Open Innovation Imperative workshop at the University of Edinburgh on the 12th January 2012. Additionally, after the first 6 month progress evaluation stage, a broad literature review began, of which would be the main focus of the first annual review with senior academics from the Department of Management Science. The outcome of this first stage was being able to identify gaps in current research and construct some basic research questions.

The *theory building and testing stages* are very closely linked in this research. The general idea for this research is that it takes an existing theoretical framework (dynamic capabilities) and applies it in an open innovation context in order to find out what processes firms go through for open innovation. Therefore, this is more suited to a deductive approach i.e. theory testing. However, at the same time, by the nature of a PhD, this research is looking to advance theory. Consequently, from writing a specific literature review that reflects the aims and questions of this research, literature from open innovation (and beyond) has been taken, and incorporated it within a dynamic capabilities framework to develop a new model in light of the literature. Therefore, this is considered to be one aspect of the theory building stage – model building from the literature. The model developed is *the open innovation maturity assessment*, and this will be tested with project teams during the innovation workshops and interviews. By listening to how research participants reflect on how they perform open innovation activities, there is confidence that open innovation theory can be advanced through identifying the capabilities needed for the strategic implementation of open innovation.

Ultimately, the data collection phase begins with a deductive-based innovation model, and throughout the empirical fieldwork and data analysis, each of these areas evolve (systematic combining) (Dubois and Gadde, 2002; Dubois and Gadde, 2014) and assist towards the development of open innovation theory. As noted by Dubois and Gadde (2002), moving back and forth from one research activity to another provides an opportunity to expand theoretical and empirical understanding of the subject. Therefore, it may be more appropriate to classify this entire research process as abduction, because of its desire to refine open innovation theory. In order to do this, both existing theory and insights gathered from the collected empirical data are combined.

In addition to the above, it was important to explicitly differentiate this research to other studies that were closely related, namely Ridder (2011) and Enkel et al. (2011).

As part of the *theory refinement process*, an initial research paper was presented at the 20th EurOMA Conference at Trinity College Dublin. Feedback received from the presentation process provided thoughtful suggestions for deliberation. Furthermore, prior to conducting the industry innovation workshops, a pilot study was performed with colleagues from the Business School. Moving this forward, another part of the theory building section will transpire as a result of the comparative multi-case study analysis. Initial findings will be discussed with the Innovation Team from the Strathclyde University Business School, which will then be translated into conference papers and journal articles.

The purpose of the *validation and evaluation stage* is to make sure that there is both a theoretical and practical contribution made as an outcome of this research. This will be the responsibility of the academic to ensure that the research was conducted in a valid way, thus ensuring reliability of research findings.

Stage	Pre-understanding	Theory building	Theory testing	Research evaluation
Activities	• Research proposal • Discussions with supervisors • Reading literature • Attend Open Innovation Imperative • Broad literature review	• Specific literature review • Model building from literature	• Pilot case study workshop • Refinement of data collection process • Conferences • Industrial workshops using model to measure open innovation performance • Interviews	• Uniqueness of research • Theoretical and practical relevance • Transferability of research • Reliability of research process
Outcomes	• Gaps in literature • Initial research questions	• Specific research questions • Open innovation maturity assessment model • Plan for empirical research	• Raw data for analysis • Case study report • Findings	• Reliable research findings • Recognised research novelty • Quality assurance

Table 11: Research stages

5.4 Case study research design

The term 'case' is frequently used as a means to bring focus upon a particular setting i.e. a group of people and/or company (Bryman, 2008), and this research strategy has 'consistently been one of the most powerful research methods in operations management' (Voss et al., 2002, 195). Meredith (1998) notes that the use of multiple methods and tools for data collection are typical of case study research. In addition, such methods include both qualitative and quantitative approaches, and possibly obtrusive and unobtrusive methods. As this thesis attempts to build theory on open innovation, there is support for adopting a case study strategy (McCutcheon and Meredith, 1993). Not only that, but a state of the art and future perspectives paper on open innovation by Huizingh (2011) called for more open innovation case study research.

Yin (2003) proposed that there are five component parts of a research design which are especially relevant for case study investigations:

1. Research questions asked
2. Its proposition, if any
3. The unit(s) of analysis
4. Logic that links the data to the propositions
5. Criteria for interpreting the findings

The general basis for starting case study work is that the researcher should have a framework in mind that will be used to carry out the investigation. This is recognised by Mintzberg (1979, 585), and he argued that, 'no matter how small our sample, or what our interest, we have always tried to go into organisations with a well defined focus.' Accordingly, the researcher is best to have a strong understanding of the subject and its main components before entering into the data collection phase. More often than not, investigations will tend to build on previous literature, and this thesis is no different. The figure below provides a useful map of the case study method employed for this study.

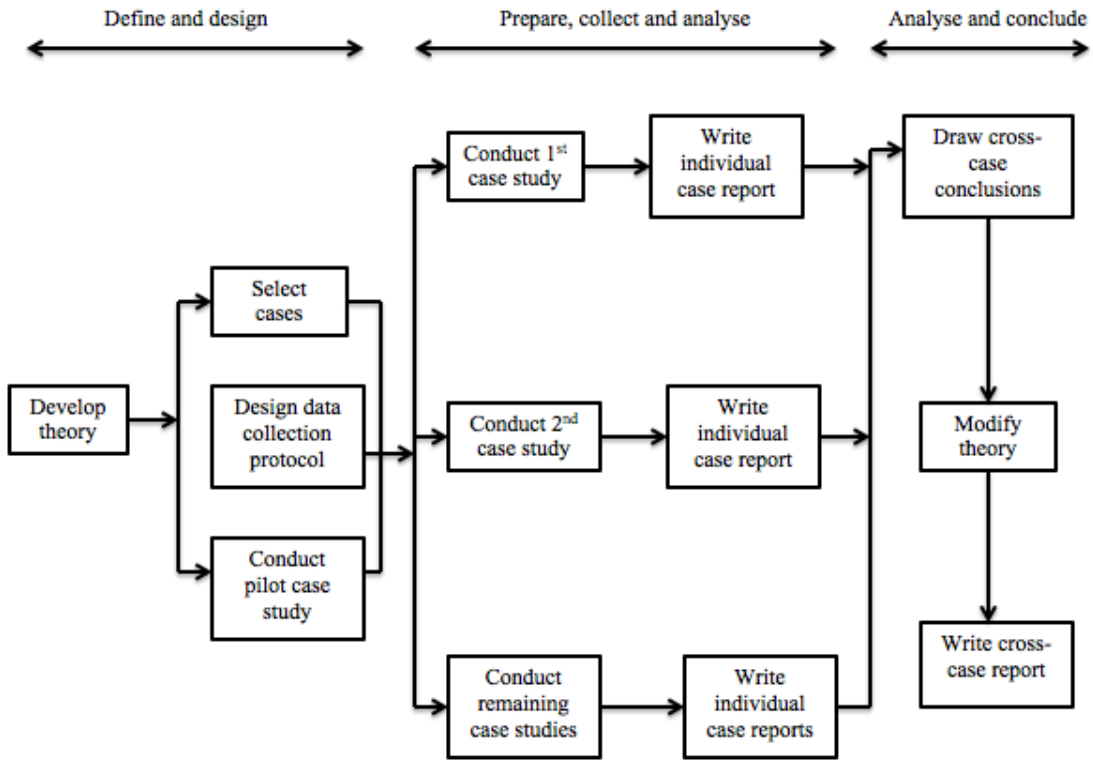


Figure 16: Case study method

Adapted from COSMOS Corporation

As already mentioned, this research begins with a theoretical framework in which to test amongst case study firms. The map above indicates that this is the starting point for case study research. Miles and Huberman (1994) provide support for this by suggesting the use of a conceptual framework at the outset explains what is meant to be studied. The next question is how to select the appropriate number of cases, and indeed what cases to use. As this research is interested in finding out performance levels of open innovation activities, and indeed the processes firms adopt to undertake inbound open innovation, a single case study strategy is not appropriate. Instead, this thesis will seek to find out this information via comparative multi-case study analysis. Choosing a multiple case approach can augment external validity and help shield from observer bias (Barratt et al., 2011). Moreover, in terms of theory building for the PhD, using multiple cases increases the likelihood for a more robust and testable theory than single case research (Eisenhardt, 1989; Eisenhardt and Graebner, 2007). Although Eisenhardt (1989, 15) mentioned that between 4 and 10 cases 'usually works well', there is greater interest in collecting a sufficient amount of data to answer the research questions, whereby collecting additional data would not alter the conclusions made. Eisenhardt (1989) stated that it would be challenging to capture the complex nature of the real world with less than 4 cases, and cognitively difficult for a researcher to process information of more than 10. Therefore, this point will be kept in mind for the selection phase of the research.

Selecting the sample cases necessitates clear criteria about what cases are to be included in the sample (Eisenhardt, 1989; Yin, 2003). As previously mentioned at

the beginning of this thesis, this research is looking to specifically investigate open innovation performance of large firms operating in the oil and gas industry. Selected firms are ones involved in new product development. For these firms, this research aims to conduct innovation workshops with specific project teams that operate within the firm's respective Technology or R&D Centre. The main priority for the innovation workshops is that the participants involved in each workshop are of the same project team, thus providing the possibility to measure individual team performance for inbound open innovation, and the processes adopted. Accordingly, selected cases are based on theoretical sampling as opposed to random sampling (Glaser and Strauss, 1967; Eisenhardt, 1989; Meredith, 1998; Yin, 2003). The overall purpose is to gather a picture of the open innovation landscape in the oil and gas industry. The assumption is that firms with a high performance rating will have more detailed processes than firms with a low open innovation maturity level.

As a guide, the following table has been used as selection criteria for choosing companies to study.

Industry	Oil and gas (Scottish Enterprise, 2012b; Technology Strategy Board, 2012)
Employees	> 1,000 (Companies Act, 2006; Cosh and Zhang, 2011; Scottish Enterprise, 2012c)
Technology orientated	Yes
Evidence of openness	Acquisitions, partnerships, license agreements, technology funding (Chesbrough, 2003; Bianchi et al., 2011; Kang and Kang, 2014)
Location to researcher	Local/some travel
Firm office	Technology R&D/Manufacturing Centre

Table 12: Firm selection criteria

One final aspect to be addressed before mentioning the case study protocol is the issue of quality. According to Eisenhardt and Graebner (2007, 26), 'sound empirical research begins with strong grounding in related literature, identifies a research gap, and proposes research questions that address the gap.' Clearly, the aim is to obtain answers to the research questions set. Yin (2003) highlighted four common tests that can be used to establish the quality of empirical research in the social sciences. This includes: construct validity, internal validity, external validity, and reliability. To make sure the researcher is equipped to conduct research, Yin (2003) provides a number of tactics that may be of use. This is illustrated in the table below.

Tests	Case study tactic	Stage of research in which tactic occurs
Construct validity	• Use multiple sources of evidence • Establish chain of evidence • Have key informants	Data collection Data collection Composition

	review draft case study report	
Internal validity	• Do pattern matching or explanation building or time-series analysis	Data analysis
External validity	• Use theory in single-case studies • Use replication logic in multiple-case studies	Research design Research design
Reliability	• Use case study protocol • Develop case study database	Data collection Data collection

Table 13: Case study tactics for four design tests

(Yin, 2003, 34)

5.5 Data collection instruments

The development of a case study protocol has been acknowledged as a useful addition within case research for improving validity and reliability of findings (Yin, 2003; Ates, 2008). Case study protocols typically include the various procedures and activities to be performed before, during, and after the data collection process. This thesis drew inspiration from the protocol used in the Manage Processes investigation by Bititci et al. (2011), and by doing so, was able to create a protocol that reflected necessary steps to be carried out for the innovation workshops (see appendix).

The process adopted for this research involved providing the key contact at the case study firm with a copy of the protocol. This allowed the firm to be more informed of the overall data collection process. The main areas of the protocol include:

- Explicitly stating the unit of analysis
    - Exploring open innovation activity in the oil and gas industry is relevant to the development of OI theory as little research has attempted to investigate this industrial setting. Moreover, in order to best capture how companies engage in open innovation, this research adopted Dahlander and Gann's (2010) perspective of openness and studied various modes of open innovation (Bianchi et al., 2011).
- Required secondary research prior to primary data collection
- Administration issues
- Detailed information on the pilot study of potential questions asked during workshops
- Written agenda and set procedures to follow during innovation workshops/interviews

    - In order to make sure that the research questions and gaps in literature were being addressed, it was necessary to have a detailed plan for gathering data. This section of the protocol was informed by the lack of knowledge surrounding the capabilities and processes required for open innovation (Enkel et al., 2009).
- Information on writing up and analysis for case study reports

5.5.1 Collecting data

Researchers have a variety of data collection instruments to choose from when conducing an investigation. In terms of case study research, Yin (2003) identified several possibilities that may be of use; archival records, interviews, observation (direct and participant), documentation, and physical artefacts. Furthermore, other options include attending meetings within the case study firm, and even having casual conversations (Voss et al., 2002). Yet, as noted by Stake (1995), the researcher should only select the instruments that will be of use to help answer the research questions.

Mentioned in the case study protocol, secondary information such as company reports, publications, annual reports, and newsletters are all important pieces of documentation that can add richness towards the researcher's understanding of the case study company and the current issues faced in the industry. In addition, interviews are clearly a critical feature of much case study research (Yin, 2003) as they can provide the researcher with detailed information from a single informant. Not only that, but interviews allow the researcher to learn multiple perspectives of a single phenomena if a cross-section of the workforce participate in interviews (Stake, 1995). Another option is for the researcher to observe the group under investigation. When doing this, it is important for the researcher to be focused on what they are meant to be observing. A useful way to keep focus is to make a documented record of observations (Yin, 2003) – from the environment in the workplace to individual behaviours. Building on the idea of taking notes, another data collection instrument is the use of a diary. This can be a convenient means for recording a series of activities over a period of time as well as having a place for personal reflection (Easterby-Smith et al., 1991).

5.5.2 Chosen research design

For the purpose of clarity, the workshop makes use of a concurrent triangulation design. This means that a mixed methods approach is adopted, through the simultaneous collection of both qualitative and numerical data in the same data collection period i.e. an Innovation Workshop (Creswell et al., 2003). In Creswell (2009), the author recommends that the reader visits Johnson et al. (2007) for an expanded view for defining mixed methods research. Accordingly, Johnson et al. (2007, 123) define mixed methods research as

> 'the type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e.g., use of qualitative viewpoints and quantitative viewpoints, data collection, analysis inference techniques) for the broad purpose of breadth and depth of understanding and corroboration.'

Despite the appeal of this definition in its emphasis on gathering data from both perspectives for added depth to the study, it would have been additionally useful if the authors mentioned that some researchers come to the data collection process with a theoretical framework before embarking on their empirical work. This is particularly true for this research, as without the initial theoretical understanding, it would not have been possible to develop the open innovation maturity assessment tables.

The decision to adopt a mixed methods approach was based on the fact that it would enable the collection of appropriate data to answer the research questions. For example, by scoring current innovation practices, and providing a description of how each activity is conducted, it is possible to understand how the case study firms innovate (RQ. 1 *How do firms currently innovate in slow clock-speed sectors?*). Furthermore, other firms can use the maturity models as a useful tool to assess their open innovation activity. By utilising the open innovation maturity models, one can assess to what extent industry has embraced the paradigm. Moreover, by predominately basing data collection on qualitative data, it is able to assess *what capabilities and processes are required for open innovation* (RQ. 2). In addition, by interpreting the responses given during the workshops and interviews, there will be potential for *identifying the key factors that could affect strategic implementation of open innovation* (RQ. 3). Finally, as firms are interested in knowing more about open innovation, both the descriptive data gathered and existing theory can be used to help *design a model of strategic open innovation adoption* (RQ. 4). These research questions are the reasons for selecting this particular research design. Although there is a numerical element to the workshops that provides a visual element to the findings, the greatest value is in the discussions had with the participants about 'how' each activity is performed.

In terms of the foundations of mixed methods research, its roots can be traced back to the middle of the 20th Century. When Campbel and Fiske (1959) became dissatisfied that it was not possible for a single quantitative method to distinguish between trait variance and unwanted method variance, they began advocating the use of several independent methods to measure the same trait. By adopting what they called a multi-trait-multi-method matrix, subjects were able to receive enhanced validation. Jick (1979) noted that the 1970s marked a distinct move away from using mixed methods purely in a quantitative manner, to one that utilised both quantitative and qualitative data sources. There was recognition that single measurement designs had strengths as well as weaknesses. Therefore, Jick (1979) promoted the use of mixed methods via quantitative and qualitative techniques in order to allow for triangulation and increased accuracy. Creswell and Plano Clark (2011) provide a summary of the evolution of mixed methods research (see table below).

Stage of development	Period	Significant features
Formative period	1959-1979	• Multiple QUAN methods • Both QUAN and QUAL • Triangulation of QUAN and QUAL
Paradigm debate period	1985-1997	• Discussed various paradigmatic stances
Procedural development period	1988-2000	• Classification system for mixed method designs • Identified types of mixed method designs • Typology development • International policy focus
Advocacy and expansion period	2003-2009	• Mixed methods as complimentary to traditional QUANT and QUAL research • Reflection on changes in mixed methods
Reflective period	2003-present	• Current state of mixed methods research • Several critiques of mixed methods

Table 14: Development of mixed methods research

Source: Creswell and Plano Clark (2011)

Since the historical perspective on mixed methods has been addressed, it is equally appropriate to identify the strengths and weaknesses of the approach. This should help provide support and justification for its use within this PhD thesis.

Positives	Challenges
• Robust findings through triangulation • Visuals can provide additional meaning to numerical data • Numerical data provides additional accuracy to visuals • Greater possibilities for breadth and depth of research questions as the researcher is not bound by a single method • Weaknesses in one method can be balanced out by strengths in another method • Ability for increased generalisability	• Researcher must learn both methods and how to use them appropriately • Difficulty for a single researcher to carry out concurrent quantitative and qualitative research • Potentially more time consuming than a single method • Added expense • May encounter difficulties in the review process

Table 15: Positives and challenges of mixed methods research

Source: Johnson and Onwuegbuzie, 2004; Davis et al., 2011)

Already mentioned by Alexander (2012), a pragmatic philosophical stance coupled with a mixed methods data collection process is extremely appropriate for doctoral research. Although turbulent at times, a PhD is arguably the first time for many researchers to have a prolonged period of time for gathering empirical data. Therefore, there is sufficient time to become familiar with multiple data collection methods and use them. Having said that, the priority of this research has always been to choose the correct methods that will help to answer the selected research questions. There is strong belief that the selected approach fulfils the objectives of the study. Specifics regarding the research design are presented below.

5.5.3 Structure of the workshops

5.5.3.1 Part I workshop structure

Given that the purpose of this thesis is to find out how firms can become better at open innovation, the industrial workshop begins with the dynamic capabilities framework (sensing, seizing, and transforming) in order to measure open innovation maturity levels. A numerical method via a maturity assessment provides a means for measuring current open innovation maturity levels of specific project teams within the case study firm (RQ. 1). This gives an understanding for what level the team is operating at with regards to open innovation maturity. Workshops are conducted at the case study company's own office for logistical reasons, as well as a desire for wanting participants to be in a setting where they feel comfortable (Creswell et al., 2003). Participants for the workshops range from R&D Managers to Research Engineers, and are chosen based on their knowledge about specific collaborative projects or technology and innovation activities within their company. The first half of the workshop is as follows (also illustrated in process map below):

1. Participants will have a folder in front of them with all the necessary documents for the session
    a. Participant information sheet
    b. Maturity assessment tables with content for sensing, seizing, and transforming
    c. Example process map

2. Researcher will deliver Power Point presentation, providing details about the purpose of the workshop and the anticipated outcomes

3. Participants will be talked through a summary of 'basic', 'intermediate', and 'advanced' for 'sensing opportunities and threats'

4. Each participant will then be asked to review the maturity table and consider how their company's processes compare to the model. Participants will then be encouraged to discuss in detail how they engage in the particular open

innovation activity. This reflects the QUAL aspect of data collection. Once the discussion is over, the researcher will ask participants to provide a figure to best reflect the firm's maturity for that activity.

5. Individual scores will be collated by the researcher and the data will be inputted into an Excel spreadsheet for subsequent analysis

6. This process will be repeated for both seizing and transforming activities

7. The data collected will then be used to create a radar chart to visually represent performance levels for inbound open innovation. The researcher will then direct focus at the measurements on the radar chart and ask the group for feedback to see if they is representative of the firm's activities. This reflects the QUAL data analysis.

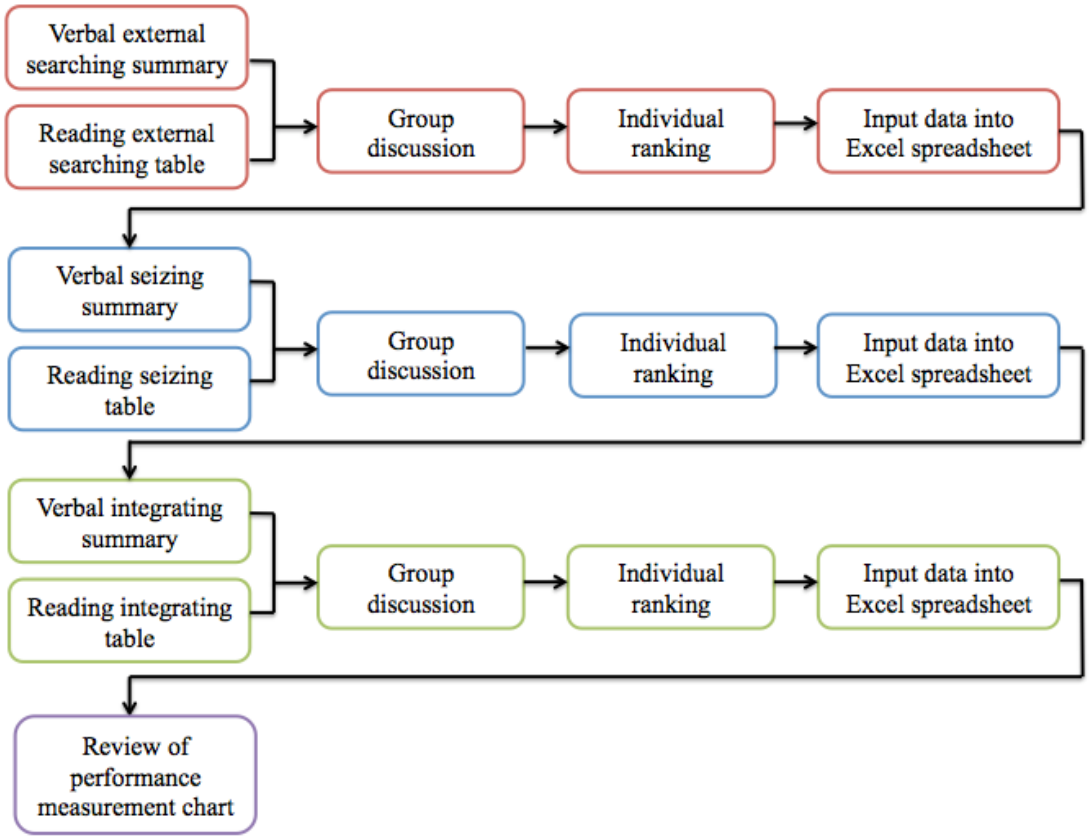


Figure 17: Process map for part I of innovation workshop

As noted in chapter three (3.7), the maturity assessment tables were developed and informed by the literature review process. The innovation workshops will make extensive use of them and it is hoped that they could be of practical use to other firms who are interested in measuring open innovation performance. The tables also offer a theoretical contribution as no other research has combined dynamic capabilities and open innovation in order to measure performance levels.

5.5.4 Maturity model for inbound open innovation

Through evaluating each performance improvement tool, it was decided to develop a deductive based inbound open innovation maturity model from the literature. The maturity model for this research utilises the SIOM maturity model template (see section 3.6.8), with 'basic', 'intermediate', and 'advanced' levels. Yet, the core elements of each maturity level found in Paulk et al. (1993) such as having defined processes, collecting and analysing data, and continual process improvement are transferred into the categories of 'basic', 'intermediate', and 'advanced' found in the SIOM template. This approach requires a degree of flexibility, as core content that represents specific maturity levels in Paulk et al. (1993) has to be adapted to fit into the SIOM template. Therefore, there will be some overlap where boundaries are concerned.

As mentioned in the evaluation section, the decision to adopt the SIOM template was made because it meant using a scale in which people are familiar with, thus reducing confusion. In addition, it is a potentially more useful scale in which to judge maturity, as the essence (content) of a 5 level model can still be included, but with a less rigid approach. Furthermore, the internal rating system within the 3 level model also acts as another maturity level assessment, and this has its benefits. For example, workshop participants will first of all have the opportunity to decide whether or not their processes for a particular activity are 'basic', 'intermediate' or 'advanced'. In addition to this, they can decide what scale they operate at i.e. 1, 2, or 3 for basic, 4, 5, or 6 for intermediate, 7, 8, or 9 for advanced. As an example, participants could say that their processes are at an intermediate level. In addition, they may acknowledge that, while they do not have basic processes, they realise that additional work has to be done before they improve on their current intermediate status. Therefore, they may decide to rate their intermediate level at 4, thus showing that they operate at the lower end of intermediate. Overall, simply providing more accuracy to the maturity scale.

After closely studying the Open Innovation Maturity Framework by Enkel et al. (2011), this research made sure to recognise its contribution, while simultaneously recognising its limitation of lacking a strategy component. However, it should be noted that the open innovation maturity model presented in this thesis was being worked on independently before Enkel et al.'s (2011) model was published. As a result, certain aspects of their work were duly noted and filter into this study e.g. the importance of management 'walking the walk'. Moreover, aside from their study using a 5 level model and this research using a 3 level model, one of the most distinguishing features between both works is the focus of analysis. Enkel et al. (2011) separate their maturity assessment into 3 elements, namely: (1) climate for innovation, (2) partnership capacity, and (3) internal processes. In contrast, this thesis bases its analysis on key areas from the dynamic capabilities literature – (1) sensing, (2) seizing, and (3) transforming (Teece, 2007). The model also includes themes for each of the above activities i.e. innovation environment, business processes, individual roles/human, and performance measurement. The tables below are copies of the maturity models used in this research to collect data.

5.5.4.1 Summary of sensing maturity levels

Basic		
1	2	3

To describe a '*basic*' level of maturity for sensing in words, this would mean that the firm has an innovation environment typical of closed innovation, whereby internal knowledge is chief. If the firm were to look outside, this may be only into industries similar to their own. Generally, the viewpoint is that external knowledge is not wanted in the organisation. In addition, the firm has not spent effort to define an external search process. There is also a lack of defined roles for external searching as this is typically an ad-hoc activity with no management or performance measurement.

Intermediate		
4	5	6

An '*intermediate*' level of maturity for sensing equates to the firm being more receptive to external knowledge, searching in their core industrial area as well as in unfamiliar areas. Moreover, knowledge is purposefully sought from suppliers, customers, and universities. In order to improve the search activity, the firm would look to undertake a process-mapping exercise of their current search activity. Furthermore, the firm looks to introduce a defined and documented process for external searching, potentially with the introduction of software to aid this activity. At this level of maturity, one would also expect to find dedicated job roles for OI, through OI managers, champions, and scouts. For performance measurement, external ideas are analysed and the search process is measured for its quality of outputs.

Advanced		
7	8	9

At the most '*advanced*' level of maturity for sensing, open innovation as an operating model is firmly cemented within the organisation, communicated, and understood by all. The firm has a strategy for open innovation and employees share that vision, with great awareness for the complimentary nature that external knowledge and technology can have on internal developments. In terms of business processes, the firm continually looks to improve upon existing search processes, as well as sharing best practice. Due to the organisational culture and behavioural awareness for OI, all employees are active in identifying opportunities. Finally, there is awareness that over-searching can have negative consequences for the business.

Sensing maturity			
Theme	**Basic** [1] [2] [3]	**Intermediate** [4] [5] [6]	**Advanced** [7] [8] [9]
Innovation environment	• *Innovation is strictly an internal activity* (Chandler, 1990; Chesbrough, 2003; Dahlander and Gann, 2010) • *Predominately searching for ideas internally with limited search of external environment* (Katila and Ahuja, 2002; Bessant and Tidd, 2008) • *Opinion that external knowledge/technology is unwanted within the firm* (NIH syndrome prevalent) (Katz and Allen, 1982; Burcharth et al., 2014) • *If external searching occurs, individuals will look in industries similar to their own (local, narrow search)* (Bessant and Tidd, 2008) • *Looking in unfamiliar, distant, and unrelated industries for new technological developments/knowledge is not common practice* (Nelson and Winter, 1982; March, 1991; Watts, 2001; West and Gallagher, 2006; Teece, 2007; Bessant and Tidd, 2008; Lee and Kelley, 2008; Chiang and Hung, 2010; Chang et al., 2012)	• *A more open approach to innovation, whereby the firm utilises both internal and external knowledge* (Freeman, 1991; Rothwell, 1994; Iansiti, 1997; Chesbrough, 2003; Landes, 2003; Chesbrough, 2006; Dahlander and Gann, 2010; Inauen and Schenker-Wicki, 2011; Chang et al., 2012; Robertson et al., 2012) • *Individuals search in their core industrial area as well as beyond their immediate business periphery (i.e. looking in distant and unrelated industries)* (Nelson and Winter, 1982; March, 1991; Burt, 1992; Laursen and Salter, 2006; West and Gallagher, 2006; Teece, 2007; Bessant and Tidd, 2008; McLaughlin et al., 2008; Chiang and Hung, 2010; Duarte and Sarkar, 2011; Chang et al., 2012; Garriga et al., 2013; Wilhelm and Dolfsma, 2014) • *Emphasis on looking in unfamiliar places* (Teece, 2007; Bessant and Tidd, 2008) • *Employees make considered effort to gather knowledge from suppliers, universities, research institutes, clients, customers, competitors, and other nations* (von Hippel, 1988; Rothwell, 1992; Li and Vanhaverbeke, 2009; Cassiman et al., 2010; Schiele, 2010; Buganza et al., 2011; Duarte and Sarkar, 2011) • *Mixture of both exploratory and exploitive search intentions* (March, 1991; Gassmann et al., 2012; Mudambi and Swift, 2014)	• *A dedicated focus on external knowledge* (Dahlander and Gann, 2010; Kutvonen, 2011) • *The importance of external searching is incorporated into the firm's strategy (organisational change)* (Meyer and Rowan, 1977; Deal and Kennedy, 1982; Katz and Allen, 1982; Nelson and Winter, 1982; Di Maggio and Powell, 1983; March, 1991; Burnes, 1992; Handy, 1999; Zahra and George, 2002; Chesbrough and Crowther, 2006; Zahra et al., 2006; Chiaroni et al., 2010; Ates and Bititci, 2011; Enkel et al., 2011; Antony et al., 2012; Kindström et al., 2013) • *The importance of external searching is communicated through corporate communications* (Katz and Allen, 1982; Dodgson et al., 2006; Chiaroni et al., 2010) • *Employees are aware of the company's focus on bringing in external ideas into the firm to complement internal technology developments* (Dodgson et al., 2006; Huston and Sakkab, 2006; Mortara and Minshall, 2011) • *Establishment of independent OI business units* (Kirschbaum, 2005) • *Develop internal system to leverage both internal and external knowledge/ideas (online platform)* (Piller and Walcher, 2006; Ili et al., 2010) • *Success stories of previous collaborations are communicated* (Paulk et al., 1993; Paulk et al., 1995; Chesbrough and Crowther, 2006)
Theme	**Basic** [1] [2] [3]	**Intermediate** [4] [5] [6]	**Advanced** [7] [8] [9]
Business processes/routines	• *No systematic process for external searching* (CIM-OSA, 1989; Davenport, 1993; Childe et al., 1994; Armistead and Machin, 1997; Zahra and George, 2002; Zollo and Winter, 2002; Winter, 2003; Chesbrough and Crowther, 2006; Helfat et al., 2007; Rohrbeck, 2010; Bititci et al., 2011; Garriga et al.,	• *Process-mapping exercise to establish current external searching activity (including waste)* (Slack et al., 2010; Modig and Ahlstrom, 2012) • *Evaluate process-map, and consider ways of improving existing processes* (Slack et al., 2010; Modig and Ahlstrom,	• *Process-mapping exercise to establish new improved processes for external searching* (Slack et al., 2010; Modig and Ahlstrom, 2012) • *Document improved process-map, communicate, and continuous improvement of the process* (Paulk et al.,

	2013)	2012) • *Searching is centred around what will benefit the firm's current products/services, as well as future endeavours* (Lee et al., 2011; Geum et al., 2013) • *The firm establishes policies and documents a defined process for external searching* (Paulk et al., 1993; Paulk et al., 1995; Winter, 2003; Chesbrough and Crowther, 2006; West and Gallagher, 2006; Asakawa et al., 2010; Sieg et al., 2010; Sofka and Grimpe, 2010; Wilhelm and Dolfsma, 2014) • *Introduction of software to aid the searching process* (Dodgson et al., 2006; Van de Vrande et al., 2006)	1993; Paulk et al., 1995; Slack et al., 2010; Antony et al., 2012; Modig and Ahlstrom, 2012) • *Best practices for searching are shared across the firm* (Paulk et al., 1993; Paulk et al., 1995; Hughes and Wareham, 2010)
Theme	**Basic** **[1] [2] [3]**	**Intermediate** **[4] [5] [6]**	**Advanced** **[7] [8] [9]**
Individual roles/human	• *Searching is done by a few individuals, but there is no official assigned roles to perform this task* (Rohrbeck, 2010; Whelan et al., 2011) • *No champions or management encouragement to promote searching the external environment* (Schön, 1963; Witte, 1973; Chakrabarti, 1974; Tushman, 1977; Fichter, 2009; Enkel et al., 2011)	• *Management encourage the act of searching externally for specialised technological developments/knowledge* (Chesbrough and Crowther, 2006; Enkel et al., 2011; Bigliardi et al., 2012) • *Manager monitors the search process* (Paulk et al., 1993; Paulk et al., 1995; Chenhall and Langfield-Smith, 2007; Chiaroni et al., 2010) • *Champions for searching the external environment are introduced* (Schön, 1963; Tushman, 1977; Chesbrough and Crowther, 2006; Fichter, 2009) • *Individuals have assigned roles for searching the external environment (Technology Scouts)* (Dodgson et al., 2006; Chiaroni et al., 2010; Rohrbeck, 2010; Whelan et al., 2011) • *Opening up and building relationships with externals* – a combination of strong and weak ties (Granovetter, 1973; March, 1991; Dittrich and Duysters, 2007; Bianchi et al., 2011; Chiaroni et al., 2011; Gronum et al., 2012) • *Individuals pass on identified opportunities to others within the organisation whom they think could benefit from the identified resource* (Whelan et al., 2011)	• *Manager manages internal OI system* • *Middle and lower-level employees are committed to bringing in external ideas to the company; organisational buy-in (culture)* (Huston and Sakkab, 2006; Kumar et al., 2011; Kaushik et al., 2012) • *Strategy of bringing in external ideas and technology is demonstrated by management who not only communicate this philosophy, but physically engage in the process* (Enkel et al., 2011)
Theme	**Basic**	**Intermediate**	**Advanced**

	[1] [2] [3]	[4] [5] [6]	[7] [8] [9]
Performance measurement	• *No measurement of search process* (Gassmann et al., 2010; Antony, 2011; Antony et al., 2012; West et al., 2014)	• *Identified opportunities are analysed and evaluated* (Marshak, 1993; Paulk et al., 1993; Arora and Gambardella, 1994; Paulk et al., 1995; Chesbrough, 2003; Chiaroni et al., 2010; Ili et al., 2010; Chiaroni et al., 2011; Berchicci, 2013) • *Searching is measured in terms of quantity and quality* (Paulk et al., 1993; Paulk et al., 1995)	• *The firm is aware that over-searching can have a negative influence on innovation performance* (Katila and Ahuja, 2002; Laursen and Salter, 2006; Chen et al., 2011; Berchicci, 2013; Li-Ying et al., 2014) • *Continuous improvement of the search process, whereby individuals are able to offer suggestions for improvement* (Paulk et al., 1993; Paulk et al., 1995)

Table 16: Sensing maturity table

5.5.4.2 Summary of seizing maturity levels

Basic		
1	2	3

If a firm were operating at a '*basic*' level of maturity for seizing, their innovation environment would generally be exhibited by a lack of initiative. As an example, individuals would not find the right people to pass ideas on to. Problematically, individuals have difficulty in seeing the value of externally developed technology or external knowledge and positively translating that into something that could be of benefit to their own organisation. One reason for this may be due to a lack of R&D activity. For business processes in regards to making contact with an external, there is no formal procedure, and this extends to having no set person to make the approach. Lastly, there is no measurement of the seizing process.

Intermediate		
4	5	6

Progressing on to an '*intermediate*' level of maturity, there is greater dynamism and entrepreneurship for seizing opportunities, with a change in mind-set about how external knowledge is perceived. Also, individuals continue with technical training to increase their intellectual capability. Like the sensing activity, process-mapping can help to establish the current process for future improvements. From this, the firm can introduce policies as well as a defined, documents approach for seizing opportunities. Compared to the basic maturity level, R&D personnel have greater awareness for the impact external technology/knowledge can have on internal developments. Dedicated job roles also help with managing the interface between the firm and the external party. At this level, individuals also make use of their extended network to bring ideas into the company. Finally, there is monitoring of the seizing process whereby management is able to track the success and failure rate of this activity.

Advanced		
7	8	9

The '*advanced*' level for maturity signals excellence in seizing. Again, employees embrace the idea of bringing in external knowledge, opting for a more open approach to NPD. Due to the firm's strategic adoption of open innovation, the firm realises that collaboration can help reduce the costs associated with internal R&D. To improve the seizing process, employees are able to communicate suggestions to remove any existing weaknesses. There is also drive and commitment to integrate the external knowledge into the business. As a step up from the intermediate maturity level, failure to seize certain opportunities are investigated for learning purposes.

Seizing external opportunities maturity			
Theme	**Basic** [1] [2] [3]	**Intermediate** [4] [5] [6]	**Advanced** [7] [8] [9]
Innovation environment	• *Limited initiative taking* (Asmawi and Mohan, 2011; Enkel et al., 2011) • *If opportunities are identified, they are not communicated – this is as far as the process goes* (Gold et al., 2001; Teece, 2007; Bititci et al., 2008; Asmawi and Mohan, 2011) • *Employees have limited experience in their field, therefore find it difficult to evaluate external knowledge* (Cohen and Levinthal, 1990; Dess et al., 2007; Jensen et al., 2007) • *Limited opportunities to improve technical expertise* (Cohen and Levinthal, 1990) • *Individuals have difficulty in seeing the value in new technological developments/service improvements outside of the firm and relating it to improving internal operations* (Cohen and Levinthal, 1990; Zahra and George, 2002; Gassmann et al., 2011; Teece, 2011; Xia, 2013) • *Individuals are not appropriately trained to capture sensed opportunities and therefore the success rate of seizing opportunities is extremely variable* (Enkel et al., 2011)	• *Entrepreneurial spirit within management to seize promising opportunities* (Witte, 1973; Rothwell, 1992; Ili et al., 2010) • *Scope for continued technical training* (Cohen and Levinthal, 1990; Paulk et al., 1993) • *Change in mind-set on how external technology/knowledge is perceived* (Katz and Allen, 1982; Burcharth et al., 2014)	• *Alter the traditional NPD process and incorporate a more open approach to innovation* (Grönlund et al., 2010) • *The firm has a suitable mix of experience and youth in technical areas, and they are able to see the value in external knowledge and external technological developments* (Hung et al., 2013) • *Employees are supportive and embrace the idea of bringing in external knowledge and utilising it for commercial gain* (Katz and Allen, 1982; Zahra and George, 2002; Chesbrough, 2003; Chesbrough, 2006; Dodgson et al., 2006)
Theme	**Basic** [1] [2] [3]	**Intermediate** [4] [5] [6]	**Advanced** [7] [8] [9]
Business processes/routines	• *The firm may make contact with the external firm/research institute/individual, but there is no defined or documented process for doing so* (Paulk et al., 1993; Zahra and George, 2002; Winter, 2003; Enkel et al., 2011) • *R&D activity is low* (Cohen and Levinthal, 1990; Berchicci, 2013)	• *Process-mapping exercise to establish current seizing activity (including waste)* (Slack et al., 2010; Modig and Ahlstrom, 2012) • *Evaluate process-map, and consider ways of improving existing processes* (Slack et al., 2010; Modig and Ahlstrom, 2012) • *Policies for seizing opportunities are put in place, defined and documented* (Paulk et al., 1993; Paulk et al., 1995; Winter, 2003; Chesbrough and Crowther, 2006; Bititci et	• *Process-mapping exercise to establish new improved processes for seizing* (Slack et al., 2010; Modig and Ahlstrom, 2012) • *R&D is still an active and important part of the firm's operations – this does not mean that the firm is required to double or triple the investment in R&D as the inflow of external knowledge/technology should help reduce R&D costs* (Cohen and Levinthal, 1990; Chesbrough, 2003; Huston and Sakkab, 2006)

		al., 2008; Asakawa et al., 2010) • *Conducting R&D is an active and important part of the firm's operations* (Cooper, 1984; Cohen and Levinthal, 1990; Arora and Gambardella, 1994; Stringer, 2000; Berchicci, 2013) • *Employees are made aware who they should pass their sensed opportunity on to (idea connector)* (Chiaroni et al., 2010)	• *The firm identifies weaknesses in the seizing process and amends as necessary (continuous improvement)* (Paulk et al., 1993; Paulk et al., 1995; Slack et al., 2010; Antony et al., 2012; Modig and Ahlstrom, 2012)
Theme	**Basic** **[1] [2] [3]**	**Intermediate** **[4] [5] [6]**	**Advanced** **[7] [8] [9]**
Individual roles/human	• *No set rules regarding who makes contact with the external* (Allen and Cohen, 1969)	• *R&D personnel have greater awareness for the impact external technology/knowledge could have on internal operations* (Cohen and Levinthal, 1990) • *Manager becomes aware of the external opportunity through the idea connector and evaluates whether or not to capitalise on it based on specific criteria* (Whelan et al., 2011) • *Manager manages interface between the firm and the external environment* (Tushman, 1977; Asakawa et al., 2010) • *Individuals make use of their networks to bring in external knowledge/technological developments* (Powell, 1990; Dodgson et al., 2006; Smart et al., 2007; Chiaroni et al., 2010)	• *When opportunities are seized, management does its upmost to integrate this with the relevant resources and assets* (Freeman, 1991; Rothwell, 1992; Szulanski, 1996; Dodgson, 2000; Laursen and Salter, 2004; Teece, 2007)
Theme	**Basic** **[1] [2] [3]**	**Intermediate** **[4] [5] [6]**	**Advanced** **[7] [8] [9]**
Performance measurement	• *No measurement of seizing process* (Gassmann et al., 2010; Antony et al., 2012; West et al., 2014)	• *Management monitors the seizing process* (Paulk et al., 1993) • Seizing rate is analysed and evaluated (Gassmann et al., 2010; Antony et al., 2012) • *Although the firm may not be able to bring in every worthy sensed opportunity, the seizing rate is adequate* (Pande et al., 2003; Antony et al., 2005; Antony et al., 2012)	• *When sensed opportunities are failed to be seized, the firm analyses this to try and determine the cause to prevent this from occurring in the future* (Paulk et al., 1993; Bititci et al., 2008; Antony et al., 2012)

Table 17: Seizing maturity table

5.5.4.3 Summary of transforming maturity levels

Basic		
1	2	3

Transforming is related to integrating externally seized opportunities into the firm. Therefore, one would categorise a '*basic*' level of maturity here as having a poor environment for collaboration, with issues of trust and IP tension between collaborating parties at the fore. Also, many project commitments and plans are based on historical experience. Overall, the environment is not very productive – managers are struggling to integrate the external knowledge and without certain people being involved the project would likely fail.

Intermediate		
4	5	6

Within an '*intermediate*' level of maturity for transforming, knowledge transfer and learning is encouraged, shown by commitment and a trusting relationship and drive towards IP resolution. The firm has a documented process for integrating resources that can be altered to suit the needs of that particular project. In terms of performance measurement, targets are set and monitored.

Advanced		
7	8	9

The successful organisation of knowledge that is put to effective use within the business helps to describe an '*advanced*' state of open innovation maturity for transforming. Moving up from the intermediate level, there is strong commitment between parties and IP issues are resolved. One needs to appreciate that this is the ideal scenario, and managing collaborative projects is rarely as fluid as this. However, businesses can strive to reach this level. Furthermore, successful collaborations are celebrated and hard work is recognised. In terms of business processes, individuals feed back on areas that worked well as well as areas that did not. Crucially, individuals are trained on how to manage partnerships. Lastly, the firm is continually seeking new ways of improving the integration process.

Integrating external opportunities (transforming) maturity			
Theme	**Basic** [1] [2] [3]	**Intermediate** [4] [5] [6]	**Advanced** [7] [8] [9]
Innovation environment	• *The firm does not have a stable environment for innovation collaboration with externals (suppliers, customers, universities etc)* (Barney and Hansen, 1994; Zaheer et al., 1998; Bogers, 2011; West and Bogers, 2014) • *Realistic project commitments are based on the results of previous collaborations* (Paulk et al., 1993) • *Collaborations tend to run behind schedule* (Paulk et al., 1993) • *Trust issues between collaborators* (Lee and Cavusgil, 2006; de Man and Roijakkers, 2009; Finch et al., 2010; Fawcett et al., 2012) • *Intellectual property tension between parties/unable to resolve* (Teece, 1986; von Hippel, 2005; Pisano, 2006)	• *Transfer of knowledge and learning between both parties is encouraged* (von Hippel, 1987; Kogut, 1991; Koza and Lewin, 1998; Lane et al., 2006; Chiaroni et al., 2010; Bogers, 2011; Westergren and Holmström, 2012) • *Commitment between both collaborating parties* (Rothwell, 1992; McEvily et al., 2003; Asmawi and Mohan, 2011; Bogers, 2011) • *Creating a trust environment between parties* (Child et al., 2005; Lee and Cavusgil, 2006; Finch et al., 2010; Jones et al., 2010; Fawcett et al., 2012) • *Intellectual property issues are worked on to find a compromising solution* (Teece, 1986; Pisano, 2006; West and Gallagher, 2006)	• Knowledge is successfully organised, mobilised, and applied to effectively and efficiently achieve organisational innovation goals (Robertson et al., 2012) • *Rewarding and celebrating success* (Gold et al., 2001; Chesbrough, 2003; Burton et al., 2006; Asmawi and Mohan, 2011) • *Strong commitment between both parties* (Rothwell, 1992; Sen and Egelhoff, 2000; McEvily et al., 2003; Asmawi and Mohan, 2011; Bogers, 2011) • *Established trusting relationship in collaboration* (Grant, 1991; Barney and Hansen, 1994; Lee and Cavusgil, 2006; Finch et al., 2010; Fawcett et al., 2012) • *Intellectual property issues are resolved* (Teece, 1986; Pisano, 2006; West and Gallagher, 2006; Hurmelinna-Laukkanen, 2011)
Theme	**Basic** [1] [2] [3]	**Intermediate** [4] [5] [6]	**Advanced** [7] [8] [9]
Business processes/routines	• *The planning and management of integrating internal and external resources is based on prior experience* (Paulk et al., 1993)	• *A process for effectively matching up internal and external resources is defined and documented* (Paulk et al., 1993; Paulk et al., 1995; Zahra and George, 2002; Winter, 2003; Chesbrough and Crowther, 2006; Todorova and Durisin, 2007; Bititci et al., 2008) • *Progress review meetings are held* (Enkel et al., 2011) • *Learning of new processes is documented* (Argyris and Schon, 1978; Senge, 1990; Herrmann et al., 2007; Hughes and Wareham, 2010)	• *Project teams provide feedback on areas that worked well so that lessons can be learned for the future* (Paulk et al., 1993)
Theme	**Basic** [1] [2] [3]	**Intermediate** [4] [5] [6]	**Advanced** [7] [8] [9]
Individual roles/human	• *Management struggle to combine relevant internal resources with the externally seized technology/specialised know-how* (Paulk et al., 1993; Eisenhardt and Martin, 2000; Helfat and Peteraf, 2003;	• *Before the collaboration begins, the project team reviews the process to make sure relevant resources have been combined* (Paulk et al., 1993; Simon and Hitt, 2003)	• *Employees are trained on how to manage partnerships* (Jones et al., 2010; Enkel et al., 2011; Fawcett et al., 2012)

	Simon and Hitt, 2003; Pavlou and El Sawy, 2011; Hine et al., 2013) • *Collaboration success depends on the competence and heroics of the people in a firm and cannot be repeated unless the same competent individuals are assigned to the next project* (Paulk et al., 1993)	• *Management makes sure project teams adhere to policies* (Paulk et al., 1993) • *Project teams tailor the firm's standard process for integrating resources and assets to suit the needs of the projects* (Paulk et al., 1993; Simon and Hitt, 2003; Hine et al., 2013)	• *High level management capability to align inbound knowledge flows with internal technology developments* (Brunswicker and Vanhaverbeke, 2014)
Theme	**Basic** **[1] [2] [3]**	**Intermediate** **[4] [5] [6]**	**Advanced** **[7] [8] [9]**
Performance measurement	• No tracking/measurement of the integration process (Gassmann et al., 2010; West et al., 2014)	• *Output targets are set and monitored* (Armistead and Machin, 1997; Zairi, 1997; Lee and Dale, 1998) • *Productivity and quality of combined resources and assets are measured* (Paulk et al., 1993)	• *Any problems that arise are investigated* (Paulk et al., 1993; McAdam and Hazlett, 2010) • *Looking for new ways to effectively manage the integration process* (Paulk et al., 1993; Koza and Lewin, 1998; Kim and Song, 2007) • *Emphasis on continually improving the integration process of external knowledge and technology into the company* (Cassiman and Veugelers, 2002; Zahra and George, 2002; Teece, 2007; Bititci et al., 2008; Gassmann et al., 2010; Ridder, 2011; Teece, 2011)

Table 18: Transforming maturity table

5.5.4.4 Objective 1 cleared

Upon reviewing the content of the maturity tables, it is believed that research objective 1 (gain a better understanding for what open innovation is) has been satisfied (see chapter one, section 1.2.1). Coupled with the R&D Management conference paper, there is a solid understanding of what open innovation is as the current literature stands. However, the view on open innovation in this thesis contrasts to what has been written about by some. Instead of thinking in terms of closed and open innovation (Chesbrough, 2003; Chiaroni et al., 2010; Chiaroni et al., 2011), there is preference towards the concept of openness, whereby the firm operates under varying degrees of openness (Dahlander and Gann, 2010; Brunswicker, 2011). This is where the main difference in opinion lies. Chiaroni et al. (2010); Chiaroni et al. (2011) talk about firms going on a journey from closed innovation to open innovation. However, this is rather a difficult concept to imagine, as it seems highly unlikely that a firm would operate one hundred per cent 'closed' and have no input from the external environment whatsoever. Hence, there is greater comfort in using the term openness. Firms participated in joint ventures, R&D collaborations, and license agreements many years before the term open innovation came around. Therefore, by being able to create the maturity models (above), greater understanding for open innovation (objective 1) has been obtained.

5.5.4.5 Part II workshop structure

The next stage of the workshop is solely qualitative.

1. The first part of the second half requires participants to work as a group to create a process map for 'sensing', 'seizing', and 'transforming' activities. This reflects the QUAL aspect of data collection.

2. The final task requires the group to sum up their strengths and weaknesses for each innovation activity

The task is then to provide each firm with a case study report based on the result of the workshops. Both numerical and QUAL data analyses will be used to produce the final report.

Triangulation designs are most commonly adopted to obtain different but complimentary data on the same topic (Morse, 1991). Triangulation is a one-stage design that enables researchers to implement both quantitative and qualitative methods in the same time frame and with equal weighting (Creswell and Plano Clark, 2011). However, as can be seen from the figure below, the weighting is more skewed towards QUAL research as opposed to numerical, although both forms are equal in terms of importance to the research. This issue is raised by Creswell et al. (2008), however they also stated that in practical applications, priority may be given to either approach. The decision to use this method was rather straightforward. In an effort to capture the necessary information to answer the research questions in a time

efficient manner, the focus was designing research that would allow for the collection of both numerical and qualitative data in the same time period. However, it should be recognised that open innovation performance is based on perception, rather than hard data on performance. Due to the valuable time contributions that the workshop participants would be offering, it was imperative to maximise the time made available. The process adopted for the innovation workshops follows the concurrent, but separate collection and analysis of data (Creswell and Plano Clark, 2011). As will be seen from the concurrent triangulation design figure below, the performance measurement section of the diagram represents the first half of the workshop, and the process mapping section depicts the process for the second half. Once the workshops are complete, both sets of data will be analysed as complimentary to one another. Following this, there should be scope to make comparisons between the levels of performance with the processes adopted by case study firms. As a result, there will be opportunity to offer suggestions for the processes and capabilities required for firms to benefit from inbound open innovation.

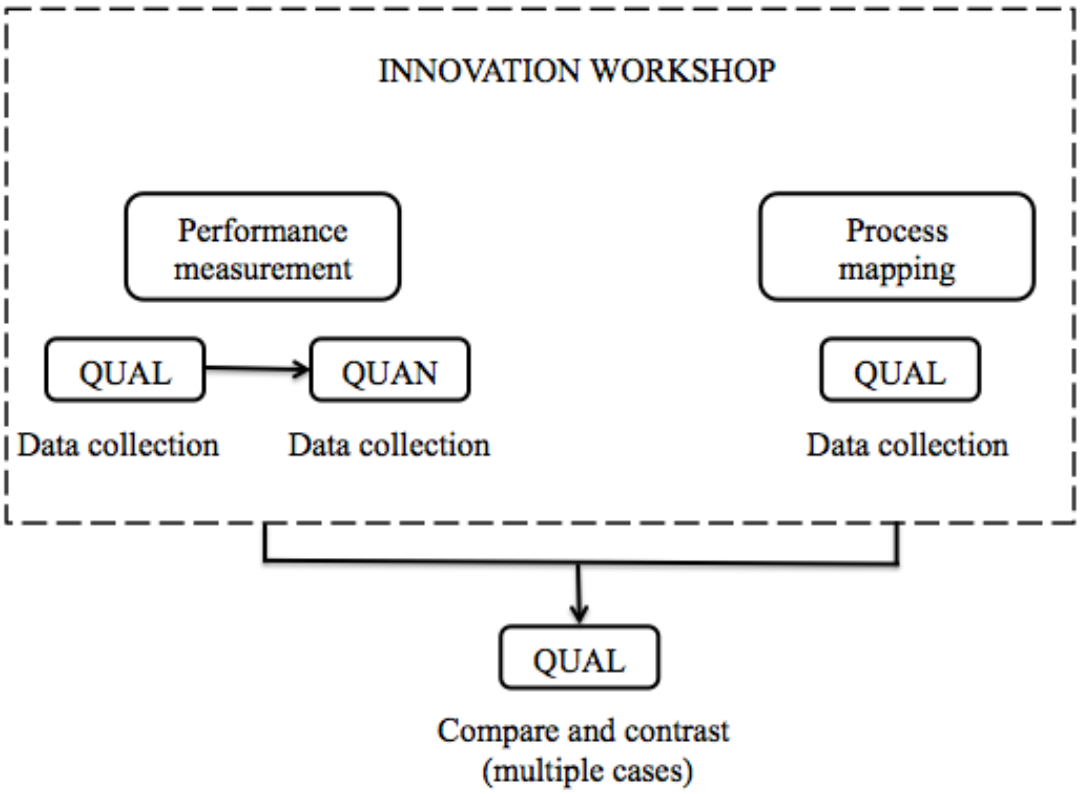


Figure 18: Concurrent triangulation design

Despite much mixed methods research opting to collect qualitative data as a first point in their fieldwork, this research is not looking to further investigate initial findings through subsequent quantitative techniques. Instead, this research is looking to identify the processes firms adopt for open innovation activities (sensing, seizing, and transforming), and then gather numerical measurements on innovation performance during the same time frame. This can then illuminate the factors to be aware of during the design of a model for strategic OI adoption. By choosing this concurrent triangulation design, there are invariably both advantages and challenges associated with its process.

Advantages of the concurrent triangulation design include:

- Shorter data collection time period compared to some sequential processes (Creswell and Plano Clark, 2011)
    - The workshop process gives the ability to answer the research questions set. It also offers the collection of data in a time efficient manner
- The model can result in well-validated and substantiated findings (Creswell, 2009)

Challenges include:

- Requires substantial efforts and expertise to use both research methods

    - A pilot of the data collection procedure and there is satisfaction regarding collecting numerical data
- Comparing the results of analyses formed from different data sets
    - Both the numerical and QUAL data collection methods ask different questions in order to answer the main research question. The results are to be used in a complimentary way, and only comparatively with other cases
- Difficulties in resolving discrepancies that arise during comparative analysis (Creswell, 2009)

5.5.5 Interviews

In instances where a case study firm is unable to commit resources to satisfy a full workshop, one to one interviews is arranged. Although every effort is made to arrange a workshop, it is realised that this can be time consuming for the firm. Therefore, in an effort to gather enough data to make a theoretical contribution, a series of interview questions were created, derived from the content of the maturity models. For example, each maturity model has four themes: (1) innovation environment, (2) business processes, (3) individual roles, and (4) performance measurement. As a result, through experience of facilitating the workshops, it became possible to develop interview questions around these areas for each open innovation activity. For instance, during a workshop, individuals will be asked to describe what processes they employ for searching the external environment for new knowledge and technology. By viewing the open innovation maturity model, one can see that business processes and routines reflect a key part of the searching activity. Moreover, the maturity model references having specific job roles for core open innovation activities; workshop participants are encouraged to elaborate on the extent of this. Similarly, for an interview scenario, interviewees would be asked to comment on the people involved in a particular open innovation task. Consequently, it is possible to create a series of interview questions that reflect what is being asked during a workshop. Interview questions can be found in the appendices section of this thesis. Overall, the data collection phase included a mixture of full workshops, single workshops, and one-to-one interviews. Single workshops followed normal workshop protocol, although only one employee is present. In terms of interviews, these were held either via teleconference or face-to-face.

As part of the research design, a schedule was put in place to attend two separate industry conferences. The first attended was Subsea Expo, Europe's largest annual subsea exhibition and conference. This event, hosted by Subsea UK, welcomed over 180 exhibitors and approximately 5,000 delegates to Aberdeen's Exhibition and Conference Centre (AECC), showcasing the latest developments in subsea technology for the oil and gas industry. Exhibitors at this event included companies such as: BP, Dril-Quip, OneSubsea, FMC Schilling Robotics, GE Oil & Gas, Fugro Subsea Services, Oceaneering, Technip, Subsea 7, Proserv, Wood Group, Kongsberg, Cortez Subsea, plus many others. The 3-day event was held from Wednesday 5th February to Friday 7th February 2014. During this time, 12 interviews with representatives from 9 different companies were performed.

The second conference attended was the 2014 Offshore Technology Conference (OTC), which was celebrating its 45th anniversary. This event is the largest conference associated with the oil and gas industry, and attracted more than 100,000 delegates to the Reliant Centre in Houston, Texas. As a result, many of the major firms engaged in R&D see this as an opportunity to showcase their latest technology to the industry. Moreover, many of the technology leaders at each respective firm attend, thus providing an opportunity to engage this research at a senior corporate level. The conference was held between Monday 5th and Thursday 8th May 2014, offering a mixture of themed technical sessions as well as expansive company booths. Highlights of this conference were interviewing the Vice President of Technology for Tree Org., Global Technology Director for Pipeline Co., Director of Technology for Integrated Subsea Org., and the Senior Vice President for Subsea Systems Org. Both Subsea Expo and OTC events were selected because of their focus on technology for oil and gas, thus providing an excellent opportunity to gather rich information. The same approach was adopted at each booth, requesting to speak to somebody with knowledge about technology and innovation at the company. This ensured that information could be gathered from the most appropriate person.

Aside from Subsea Expo and OTC 2014, one-to-one interviews were arranged with individuals occupying various job roles. These included Lead Research Engineers, Technology Managers, and Sales Managers to name a few. Those selected for interview were chosen because they had an appreciation for technology and innovation activities within their company. These pre-arranged interviews typically lasted between one and two hours, and took place at the firm's Technology R&D or Manufacturing Centre.

5.6 Introducing the case study firms

For the purposes of confidentiality, the following cases will assume anonymity by omitting every company's official name. In turn, fictional names will be used in conjunction with industrial classifications obtained from the online database, FAME. The fictional names used are based on the nature of the firm's business. This research investigates three firms in-depth (Pipeline Co., Valve Co., and Tree Org.), while the other cases were more opportunistic.

5.6.1 Pipeline Co. (PC01)

Pipeline Co. is a global subsea engineering company with expertise in design, fabrication and installation of seabed-to-surface applications for the offshore oil and gas industry. Officially, the primary UK SIC code for the company is 09100 – support activities for petroleum and natural gas extraction. In addition, the trade description is as follows: the provision of high technology welding and construction for subsea and cross-country pipeline projects. Globally, the firm has a resource of over 12,000 people. This firm was selected for investigation as they had a live and

on-going open innovation project which the Managing Director was enthusiastic to share.

Two distinct cases were studied at Pipeline Co, and the data for each case was collected at the same location, except on separate occasions. The first case investigated deals with a technical partnership between Pipeline Co. and another pipeline construction company based in Houston, called Weld Tech (WT02). The trade description for Weld Tech is: the provision of technical solutions to help clients boost speed, efficiency, productivity and quality in the welding industry. Their UK SIC code is 96090 – other personal service activities n.e.c. Similar to Pipeline Co, Weld Tech provides pipeline construction equipment for their clients through the use of automatic welding technologies. This case was chosen because it provides an illustration of open innovation in action within the oil and gas industry. Participants in this first workshop were members of Pipeline Co's Management Team involved in the technical partnership with Weld Tech. This included the Managing Director, Commercial Manager, and Technical Manager of the Pipeline Group.

The second case from Pipeline Co. was less bounded by a specific joint venture or partnership. Instead, the study was concerned with the firm's approach to innovation within the Pipeline Group. This workshop was conducted with members of the Innovation Management Team at Pipeline Co. This included the Welding Technology Manager and the R&D Manager. For both case investigations, the innovation workshops were held at Pipeline Co's R&D Welding Technology Centre in Scotland. This site supports 150 jobs from engineering to project management, and highly skilled welding.

NB: This firm <u>does not</u> communicate the term open innovation (in external press).

5.6.2 Umbilical Co. (UC03)

Umbilical Co. provide project management, engineering and construction solutions to the energy industry. The firm's primary UK SIC code is 09100 - support activities for petroleum and natural gas extraction. As outlined on the FAME database, their trade description is: a fully integrated subsea contractor and supplier of subsea products. The firm has a global human resource of approximately 40,000 employees.

This particular firm was chosen because they would offer a unique insight into open innovation in comparison to several others within this thesis as they openly communicate the term open innovation in press. Data gathered here is concerned with the firm's approach to innovation rather than any specific mode of open innovation. Interviews were conducted with the manager responsible for open innovation within the firm (Innovation and Partnerships R&D Manager) who operates out of their Innovation and Technology Centre in France. This research centre specifically focuses on subsea technology R&D. Three other interviews were undertaken, one with a Project Engineer discussing R&D activities emanating from their Aberdeen research division, another with a Procurement Manager giving insight

into knowledge sharing, and a final interview with a Project Manager who also gave an Aberdeen perspective to innovation within the firm.

NB: This firm communicates the term open innovation (in external press).

5.6.3 Valve Co. (VC04)

Valve Co. is a global engineering solutions provider who design, manufacture, and support a range of valve, pump and turbine technologies for the energy industry. The FAME database indicates their primary UK SIC code as 70100 – activities of head offices. Moreover, their trade description is: engineering group operating within three divisions: Minerals, Oil & Gas, and Industrial. This firm operate in over 70 countries and has a talent pool of over 14,000 employees. The decision to select this business for further enquiry is based on their recent growth an expansion through their multiple acquisition activity. In addition, there was interest to understand more about their open innovation activity in relation to university R&D programmes.

One of the cases studied within Valve Co. involves their oil and gas business, Valve O&G Co. (VOG05). This case investigates how this part of the business engages in open innovation activities. There is also crossover discussion about their R&D Centre. For this workshop, an individual in charge of scouting external technology was present (Technology Analyst), as well as the Engineering Excellence Manager. Other collected data was via face-to-face interviews, enabling the capture of insights from employees across all three of the firm's operating divisions (Valve O&G Co., Valve Mine Co., and Valve Power Co.).

NB: This firm <u>does not</u> communicate the term open innovation (in external press).

5.6.4 Tree Org. (TO08)

Tree Org. is a market leader providing technology solutions to the global energy industry. The firm design, manufacture, and service sophisticated onshore and offshore equipment such as subsea production systems, X-mas trees, pressure control systems, and measurement solutions for oil and gas companies. The FAME database lists their primary UK SIC code as 09100 - support activities for petroleum and natural gas extraction. In addition, their trade description is: a group engaged in the manufacture and marketing of oilfield and wellhead equipment, flow measurement and control equipment. The firm employs over 18,000 people.

Data from this firm was primarily collected from the firm's Subsea Technology R&D Centre in the UK. Two single workshops specifically investigated innovation processes within the firm's emerging technologies group i.e. Optoelectronics Group. Additional data was collected from engineers working in the R&D Centre for specific teams in the Product Group. The R&D Centre employee headcount is

expected to reach 170. This company was chosen for investigation due to their market leading status, and also because of their engagement in open innovation activity as evidenced by R&D partnerships with universities.

NB: This firm does not communicate the term open innovation. However, during a 15 month research placement at the firm, it was found that one document confirmed that the Optoelectronics Group employs open innovation practices.

5.6.5 Tech Wellhead Org. (TWO10)

Tech Wellhead Org. is a technology and services leader, encompassing all segments of the oil and gas industry (E&P, midstream, and downstream). The firm's primary UK SIC code is 82990 – other business support activities n.e.c. Furthermore, their trade description is: the design, manufacture and sale of drilling and completion equipment used in oil and gas exploration and production, and the provision of installation and operation services. Tech Wellhead Org. is one business unit of a much larger organisation that has specialist capability in a number of industrial areas e.g. power generation (Tech Hydro Org.), mining, renewables, healthcare, and aviation (Tech Aeronautics Org.) to name a few. Tech Wellhead Org. employ in excess of 43,000 people who operate in over 100 sites.

Interestingly, the multinational group that fronts all of the different industrial areas of this corporation communicate the idea of open innovation. This communication is much more at the group level as opposed to each industrial business e.g. oil and gas, renewables, healthcare etc. To gauge a sense for open innovation activity in the oil and gas business, insight was gained through interviews with the CEO Subsea Systems, as well as the Technology Manager for Intellectual Property and Knowledge Management, and also other Managers from this global conglomerate. This particular company was selected as a case study because they choose to associate themselves with open innovation. Therefore, this would provide an opportunity to better understand how firms engage in open innovation.

NB: This firm communicates the term open innovation (in external press).

5.6.6 Hardware Co. (HC13)

Hardware Co. is a manufacturer of offshore production and drilling equipment. The firm designs and manufactures subsea, surface, and offshore rig equipment for oil and gas companies. FAME database lists their primary UK SIC code as 25110 - manufacture of metal structures and parts of structures. Their trade description is: a group engaged in the sale, rental, design, manufacture, testing, and in house refurbishment of drilling and production equipment. The decision to select this firm as a case is based on the fact that they design and manufacture similar products to

others within this study. The aim was to find out the different innovation practices performed by firms who operate in similar areas.

NB: This firm does not communicate the term open innovation (in external press).

5.6.7 Integrated Subsea Org. (ISO14)

Integrated Subsea Org. provides oil and gas companies with integrated solutions for their field development. This company was created out of a joint venture, combining expertise and capability in flow control, process technology, and manufacturing from Control Systems Org. (CSO16) with excellence in reservoir imaging technology and R&D from Oilfield Services Co. (OSC15). The firm's primary UK SIC code is 28990 – manufacture of other special-purpose machinery n.e.c. Their trade description is: the design and manufacture of engineering products for the oil, gas transmission, electrical and other engineering industries. This firm was chosen because it provides an interesting example of open innovation in practice.

NB: This firm does not communicate the term open innovation (in external press).

5.6.8 Exploration Co. (EC17)

Exploration Co. is a leading producer and supplier of hydrocarbons (oil and natural gas). The firm has significant presence in the United States and the Gulf of Mexico. The primary UK SIC code is 06100 – extraction of crude petroleum. The firm's trade description – exploration and production of crude oil and natural gas, refining, marketing, supply and transportation, manufacturing and marketing of petrochemicals. Also active in gas power and solar power generation. As one of the largest firms in the industry, they employ close to 84,000 staff. The information below provides detail for the main reasons for selecting this firm as a case study.

NB: This firm communicates the term open innovation (in external press). Additionally, Henry Chesbrough has publically interviewed the firm's Head of Technology about their open innovation activity.

5.6.9 Offshore Solution Org. (OSO18)

Offshore Solution Org. provide a variety of engineering services to the energy industry. Their primary UK SIC code is 09100 – support activities for petroleum and natural gas extraction. Also, their trade description is – the provision of management, engineering maintenance and support services to the offshore and onshore oil and gas industry. The firm employs approximately 46,000 people throughout their business.

While this research is predominately weighted towards manufacturing organisations, recent open innovation literature expressed a desire to learn more

about service organisations and their open innovation activity. Selecting this case is built on a desire to provide knowledge for this gap, but is also based on initial discussions with managers about the company's transition towards addressing their innovation core value.

NB: This firm does not communicate the term open innovation (in external press).

5.6.10 Subsea Systems Org. (SSO21)

Subsea Systems Org. is a service provider of technology systems and solutions to firms in oil & gas, marine, defence, and aerospace industries. Their primary UK SIC code is 32990 – other manufacturing n.e.c. The trade description for the part of the group under investigation here is – the design, manufacture and sale of underwater cameras and systems for the offshore and ocean science industries and the sale and service of marine electronic systems. The Group employs in the region of 6,500 people, and operate in 25 countries. Known for their technological sophistication, there was interest to learn more about their approach to innovation – this is why Subsea Systems Org. was selected for studying.

NB: This firm does not communicate the term open innovation (in external press).

The table below provides further details from the cases used within this study.

Company	Firm size	Total no. employees interviewed	Job role	Data collection location	Data collection method	Duration	Date
Pipeline Co.	>14,000	7	Managing Director PPG	Technology Development Centre, Scotland	Workshop	2 hours 5 minutes	1st August 2013
			Technical Manager				
			Commercial Manager				
			R&D Manager	Technology Development Centre, Scotland	Workshop	1 hour 20 minutes	6th August 2013
			Welding Technology Manager				
			Bundle Design Manager	Subsea Expo, Aberdeen	Interview	20 minutes	6th February 2014
			Global Technology Director	OTC, Houston	Interview	20 minutes	6th May 2014
Umbilical Co.	>36,000	4	Innovation and Partnerships R&D Manager	Innovation and Technology Centre (teleconference), France	Interview	1 hour	29th January 2014
			Project Engineer	Online, Canada	Single workshop	1 hour	20th January 2014
			Project Manager	Subsea Expo, Aberdeen	Interview	30 minutes	6th February 2014
			Procurement	OTC, Houston	Interview	40	7th May

			Business Services Manager			minutes	2014
Valve Co.	>14,000	12	Technology Analyst	R&D Centre, Scotland	Workshop	2 hours 30 minutes	9th December 2013
			Engineering Excellence Manager				
			Director Oil & Gas Forum	University of Strathclyde, Scotland	Interview	20 minutes	3rd February 2014
			Commercial and Projects Manager		Interview	20 minutes	
			Project Planner		Interview	20 minutes	
			Product Development Manager		Interview	20 minutes	
			Senior Engineer R&D		Single workshop	1 hour	4th February 2014
			Supply Chain Analyst		Interview	10 minutes	
			Regional Sales Manager – Middle East		Interview	10 minutes	
			Sales Manager		Interview	10 minutes	
			Director Dewatering Systems	OTC, Houston	Interview	40 minutes	6th May 2014
			Product Specialist	OTC, Houston	Interview	10 minutes	6th May 2014
Tree Org.	>18,000	7	Design Engineer	Subsea R&D Centre, Scotland	Single workshop	1 hour 10 minutes	7th February 2014
			Sales and Business Development Manager	Subsea Expo, Aberdeen	Interview	20 minutes	6th February 2014
			Lead Research Engineer	Subsea R&D Centre, Scotland	Single workshop	30 minutes	7th March 2014
			Research Associate	University of Strathclyde, Scotland	Single workshop	2 hours	13th February 2014
			Graduate Engineer	Subsea R&D Centre, Scotland	Single workshop	1 hour	7th March 2014
			Vice President, Technology	OTC, Houston	Interview	20 minutes	7th May 2014
			Sales and Marketing Manager	OTC, Houston	Interview	10 minutes	5th May 2014
Tech Wellhead Org.	>305,000	6	Business Development Manager	Subsea Expo, Aberdeen	Interview	30 minutes	6th February 2014
			MAPS Production Director		Interview	30 minutes	
			CEO, Subsea Systems	Subsea Systems HQ (teleconference)	Interview	50 minutes	3rd March 2014
			Technology Manager – IP and	Manufacturing and R&D Centre, Newcastle	Interview	30 minutes	12th March 2014

			Knowledge Management	(teleconference)			
			Strategic Marketing Manager	HQ, New York (teleconference)	Interview	20 minutes	4th March 2014
			Business Development and Marketing Manager	OTC, Houston	Interview	20 minutes	6th May 2014
Hardware Co.	>2,400	1	Project Sales Manager	Subsea Expo, Aberdeen	Interview	30 minutes	6th February 2014
Exploration Co.	>85,500	2	Flow Assurance Engineer	Subsea Expo, Aberdeen	Interview	10 minutes	6th February 2014
			Subsea Hardware Engineer		Interview	20 minutes	
Integrated Subsea Org.	>6,000	2	Account Manager	Subsea Expo, Aberdeen	Interview	30 minutes	6th February 2014
			Director of Technology	OTC, Houston	Interview	10 minutes	6th May 2014
Offshore Solution Org.	>43,000	2	Design Team Lead	Subsea Expo, Aberdeen	Interview	20 minutes	6th February 2014
			Global Head of Innovation and Knowledge Management	Teleconference, Aberdeen	Interview	30 minutes	12th February 2014
Subsea Systems Org.	>7,490	3	Sales Manager Offshore Rental	Subsea Expo, Aberdeen	Interview	20 minutes	6th February 2014
			Sales Manager Offshore Production Systems		Interview		6th February 2014
			Senior Vice President, Software and Services	OTC, Houston	Interview	40 minutes	5th May 2014
Total employees		46					

Table 19: Case data

The firms under investigation within this study are classified as operating internationally in the energy sector. More specifically, the majority of them are oil and gas companies, and a small number of them have operations in other industries. Furthermore, these firms include a mixture of operators (oil exploration), EPCs (engineering, procurement, and construction), made-to-order technology production companies. A proportion of them also have expertise in subsea technology, while two firms are service providers. As part of the data collection phase, research objective 2 (explore how firms engage in open innovation), and research objective 3 (investigate the processes related to open innovation and how outputs are measured) have both been achieved. The collected empirical data has provided adequate information to satisfy both objectives, signalling that all research objectives have been cleared prior to beginning data analysis on NVivo.

5.7 Limitations of data collection

Having awareness about the limitations of particular data collection methods is a necessary component of research. The subsequent text outlines some of the limitations associated with the data collection stage in this study.

- Restricted access:

(1) The organisation

Despite identifying a number of suitable companies operating in the oil and gas industry, some were unwilling to participate in the study. One firm felt that discussing innovation practices was too sensitive a subject to be had with an outsider. Additionally, another firm felt that they did not need academic input about innovation, as they were already a successful and innovative company. Moreover, by far the most common obstacle was receiving no response after contacting the firm. No response in terms of trying to establish interest in the study, but also no response after arranging interviews. On one occasion, a Power Point presentation was delivered to three senior members of a management team (all of whom were very enthusiastic about the subject and mentioned getting people from other company offices involved), but once it came time to organise dates for the workshops none of the individuals replied to any correspondence.

Restricted access to organisations was overcome by attending Subsea Expo in February 2014. At this event, company representatives were very accommodating and happy to provide information to support this PhD study. On more than one occasion, contact details for Senior Technology Managers at their respective companies were given. Moreover, on a note towards industry conferences, obtaining data at OTC was more challenging than at Subsea Expo. When speaking to exhibitors, there was some resistance by individuals to answer questions if this was not directly associated with their job. It should be noted however that three cases were explored in-depth, and the others were more opportunistic.

(2) Personnel

On the whole, the most challenging aspect was finding contact details of the most relevant people to approach. In addition, trying to persuade management to offer up their time as well as their staff was challenging. Despite best efforts, this resulted in a situation whereby not all data was able to be collected via an innovation workshop. The reality was that collecting information in this way would be the ideal scenario, however this proved to be more challenging than initially anticipated. Therefore, although some of the data has been gathered from industry workshops, interviews were conducted to supplement the workshop data.

(3) Location

Due to the fact that open innovation in this study is largely associated with new technology and knowledge, there was a desire to seek out Innovation/Technology Centres where the targeted firms had a physical presence. At this time, it was fortuitous that there are a number of technical sites local to the university

campus. Therefore, this locality reduced the requirement for sourcing significant travel funds.

(4) Information
Even although this research was not interested in obtaining any sensitive information, some participants may have omitted certain facts during the workshop or interview process. Despite there being no immediate evidence to suggest this, there is a chance that some interviewees restricted information to preserve the interests of the company. Also, because the workshops required participants to measure performance subjectively, not only would there be bias towards their assessment (because they do not want to appear to be poor at innovation despite being a technology company), but their description of activities did not always measure up according to the maturity scale. Therefore, although some individuals might have given a high score, their descriptive evidence did not always necessarily support this. Consequently, the researcher is tasked with assessing a more accurate state of open innovation performance in light of all the data gathered.

Another area related to information obstacles is that despite all full industrial workshops (>1 individual present) completing the workshop, reduced data was able to be collected for the single workshops. For example, not all single workshops were able to perform the process mapping exercise or go into detail about the strengths and weaknesses of each innovation activity. Additionally, some interviews at the conferences were very short, making it challenging to explore questions beyond the innovation environment and the process for searching for knowledge. However, during this short period it was possible to gain a sense for an employee's awareness of open innovation, and whether or not the company was actively and strategically engaging in it. Certainly, in an ideal world it would have been great to ask more questions, but there is confidence that enough data has been collected overall to make a worthwhile contribution to knowledge.

The next section of this thesis offers thoughts on how the collected performance measurement data can be effectively integrated with the process mapping qualitative data. This chapter concludes with a summary on research design.

5.8 Integrating numerical and QUAL data

A key aspect of any research project is in the analysis of the data collected, a point supported by Eisenhardt (1989). In a similar turn, she also emphasised that it is possibly one of the most challenging parts of the research process. As this project adopts a mixed methods approach, there are certain points that need to be taken into consideration. One of which is the method towards analysis. According to Creswell (2009), the mixing of methods during a concurrent triangulation strategy occurs in a discussion section of the analysis chapter. The idea is that both numerical and QUAL data can be merged, integrated or compared side by side in a discussion (Creswell, 2009). This is exactly the process that will be adopted within this thesis, for this

research is not dependent on a previous section being completed before analysis can begin. This research takes inspiration from Miles and Huberman (1994) and has chosen to overlap data collection with data analysis so as to alleviate the burden of analysing all data at the end. Once all cases have been individually analysed, they will then be compared against once another so that conclusions can be drawn.

5.8.1 Data analysis options

Typically, there are three operations available to researchers that wish to analyse qualitative data. Miles and Huberman (1994) outline these possibilities as:

- **Data reduction** - the process of selecting, focusing and simplifying collected data
- **Data display** – a visual representation of the gathered information for conclusions to be drawn
- **Analysing data and drawing conclusions**

Specifically for data reduction, documentation and coding represents two viable options for researchers. Firstly, documentation can involve writing up summary sheets based on site visits, meetings (Miles and Huberman, 1994), and in this instance – reflective thoughts based on each innovation workshop. As indicated by Voss et al. (2002), ideally this task should be performed as soon as possible after the meeting has taken place so that the researcher mitigates the chance of failure to recollect information. For coding, this is associated with attaching specific codes to sections of words. In turn, this enables the researcher to file the data into specific categories for subsequent analysis (Glaser and Strauss, 1967). Software packages such as NVivo would be the recommended choice as it is widely used throughout the university and is therefore easily accessible.

The use of data displays is strongly advocated by Miles and Huberman (1994) as a means to describe and explain specific cases. This process is identified as being the second stage of analysis that represents 'an organized, compressed assembly of information that permits conclusion drawing and action' (Miles and Huberman, 1994, 11). This involves a visual representation of information that is laid out in a systematic manner so that the researcher can answer his/her research questions. Matrixes, critical incident charts, and event listings are cited as being potential ways for displaying data (Miles and Huberman, 1994).

Once the collected data has been arranged in a form that is suitable for analysis, the researcher is tasked with analysing that data and drawing conclusions. Authors have tended to distinguish between within-case analysis and cross-case analysis (Eisenhardt, 1989; Miles and Huberman, 1994). Generally, the researcher will be interested in gaining a thorough understanding of the case in front of them before undertaking a larger comparative study. Highlighted by Miles and Huberman (1994), within-case analysis focuses attention towards explanation and causality. They propose a series of methods for analysing data, namely:

- **Exploratory effect matrixes** – used as a first point of contact for gaining understanding as to why something has happened

- **Case dynamic matrixes** – highlights potential forces for change and tracks the consequential processes and outcomes

- **Causal networks** – illustrate important independent and dependent variables, and their relationships among each other

- **Making and testing predictions** – the researcher makes predictions and uses the data derived from the case study to test them
  (Miles and Huberman, 1994)

Conversely, cross-case analysis looks to compare data across multiple cases. For one, researchers may be interested in finding out differences and similarities between companies in the same sector. Also, there might be a desire to provide a generalisable set of assumptions about a particular group or industry (Miles and Huberman, 1994). Again, Miles and Huberman (1994) present various analytical options for researchers. One such option would be to construct a matrix that has specific categories. The researcher could then input the appropriate data, thus enabling the possibility to highlight similarities and differences between cases. Another avenue could be to select two cases, perform the same activity as above, and then conduct comparative analysis.

5.8.2 Chosen data analysis instruments

Due to the fact that this study begins with an existing theoretical framework, this already provides structure and a pre-existing specification of categories where data can be assigned to (Hussey and Hussey, 1997). Therefore, data gathered from workshops and interviews will be assigned into categories of sensing, seizing, and transforming activities and transcribed verbatim within an Excel spread sheet. From this, any interesting quotes and/or key messages given by interviewees are highlighted in red so that the text can be extracted during the write-up phase. There will be opportunity for group participants to reflect on performance measures given. Here, the research will make use of data displays in the form of explanatory matrixes. The researcher will subsequently produce a summary of observations based on the data gathered. Output from the first half of the workshop will subsequently include (1) a performance measurement graph i.e. the project team's open innovation footprint and (2) matrixes with content that provides explanations for the eventual assessment given.

Part two of the innovation workshop adopts the process mapping technique. Predominately used in operations management, this is one of the major data display outputs of the research. The purpose of which is to visually highlight the processes performed for open innovation activities. To conclude the workshop, participants will summarise both their strengths and weaknesses for sensing, seizing, and transforming activities. Similar to the previous section, data will be displayed in

matrixes with the researcher offering their own concluding comments. To address the issue of data reduction, coding sections of related text into themes will be undertaken. Making use of the available licensed QSR NVivo 10 software, appropriate Word documents are set up so that all of the text from the Excel spreadsheet can be uploaded for analysis.

In terms of analysing data gathered from one-to-one interviews, respondent data is written up underneath each question on the question sheet. Similar to the approach for the workshop data, key quotations are highlighted in red for subsequent use in answering the research questions. All relevant data will be classified into themes and text will be drawn from the NVivo database during the writing up phase. For instance, under the 'sensing' category on NVivo, the following bullet points provide examples of themes included for coding:

- Innovation environment (Bessant and Tidd, 2008)
- Knowledge sources (von Hippel, 1988; Rothwell, 1992)
- NIH syndrome (Katz and Allen, 1982)
- Strategy (Teece, 2007)
- Business processes (Rohrbeck, 2010; Bititci et al., 2011)
- Software (Dodgson et al., 2006; Van de Vrande et al., 2006)
- Individual roles (Schon, 1963; Rohrbeck, 2010; Chiaroni et al., 2010; Whelan et al., 2011)
- Encouragement (Enkel et al., 2011)
- Performance measurement (Slack et al., 2006; Gassmann et al., 2010)

Similarly, under the 'integration' category on NVivo, other themes include matters related to:

- Collaboration environment (Bogers, 2011; West and Bogers, 2014)
- Intellectual property (Teece, 1986; Pisano, 2006; West and Gallagher, 2006)
- Knowledge transfer (von Hippel, 1987; Bogers, 2011; Westergren and Holmstrom, 2012)
- Trust (Lee and Cavusgil, 2006; de Man and Roijakkers, 2009)
- Learning (Paulk et al., 1993; Enkel et al., 2011)

In the interest of finding out the differences between each case study, the research will explore the data and perform cross-case analysis. By doing this, there will be opportunity to provide an assessment of the state of open innovation performance and processes for these companies. Ultimately, cross-case analysis can increase internal validity for a construct (Voss et al., 2002). The data analysis section will comment on the main themes highlighted above. Furthermore, for data display purposes in this thesis, data is organised into summary diagrams (matrix). This will be provided at the end of the analysis section.

5.9 Conclusions

Following on from research methodology, the research design chapter provided an opportunity to express the data collection and analysis procedure for this study. The nature of the research questions has been a guide towards mixed methods research; a common data collection method associated with pragmatism. Therefore, the problem areas influenced the research methods and research strategies. As there was a need to examine the accuracy of Chesbrough's (2003) paradigm shifting claim, it was necessary to understand how companies engage in open innovation. In order to best serve an answer for this question, a deductive approach was adopted, as this would give a strong theoretical grounding and therefore an ability to challenge Chesbrough's comments. To do this, a multi-case study strategy was employed allowing an ability to gain a variety of perspectives from several organisations concerning the extent to which open innovation had been strategically adopted within industry.

Through the use of an open innovation maturity model, it was possible to critically assess three core activities of open innovation along four themes: innovation environment, business processes, individual roles, and performance measurement. Following a series of interviews and innovation workshops, data was coded using NVivo 10 software, which resulted in performing a thematic analysis and pattern matching exercise. From this, it was possible to gain an appreciation for the capabilities needed for successful open innovation, and what open innovation could look like if it was incorporated into strategy. The limitations of this study are noted in section 5.5.5. Next, chapter 6 provides insight into open innovation practices within specific cases from the oil and gas industry.

Chapter 6. Individual case study analysis

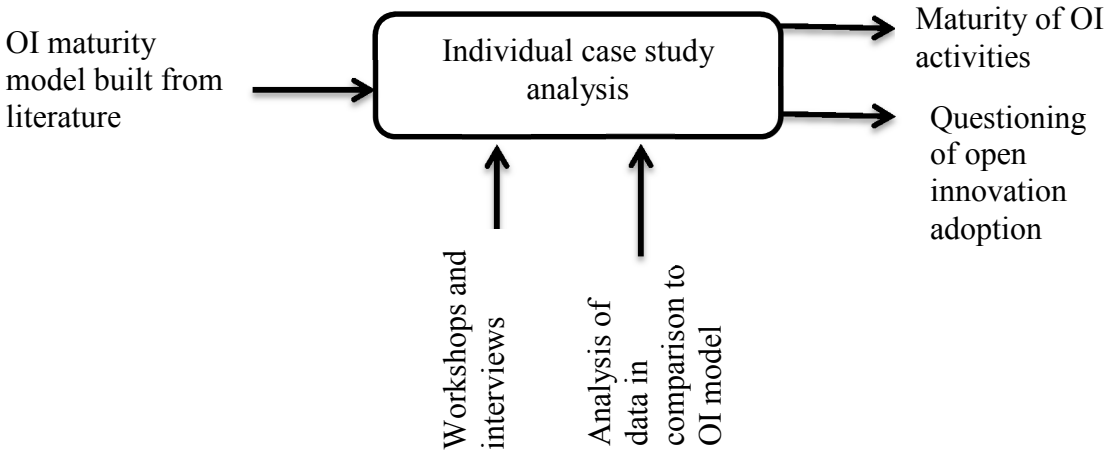


Figure 19: Chapter 6 input - output diagram

6.1 Introduction

This chapter will provide detailed insight into three of the firms studied within this research. The decision to document these cases in detail is due to the fact that each one provides a unique and individual background scenario of open innovation activity. Furthermore, these cases offer insight into the firms that performed a maturity assessment using the OI maturity model to assess their activities. As a result, this chapter explores open innovation maturity from Tree Org., Pipeline Co., and Valve Co. Each case begins by presenting their participant open innovation footprint, followed by a table to illustrate the scoring system. Next, supplementary information on the innovation environment, business processes, individual roles, and performance measurement is given as evidence. Also, in an effort to provide balance, a critical assessment of each firm's level of open innovation maturity is calculated based on reflection from the OI maturity model that was developed from existing literature. Finally, each case concludes by providing a short summary on their OI maturity.

6.2 Tree Org.

6.2.1 Participant maturity assessment

As highlighted in chapter 5, all of the individuals from Tree Org. who participated in the open innovation maturity assessment are based at the firm's Subsea R&D Centre. Therefore, these individuals are extremely well placed to provide an accurate account of the company's operations in relation to innovation. The radar chart below (open innovation footprint) provides a visual representation of the participants view concerning three key open innovation activities (sensing, seizing, and transforming).

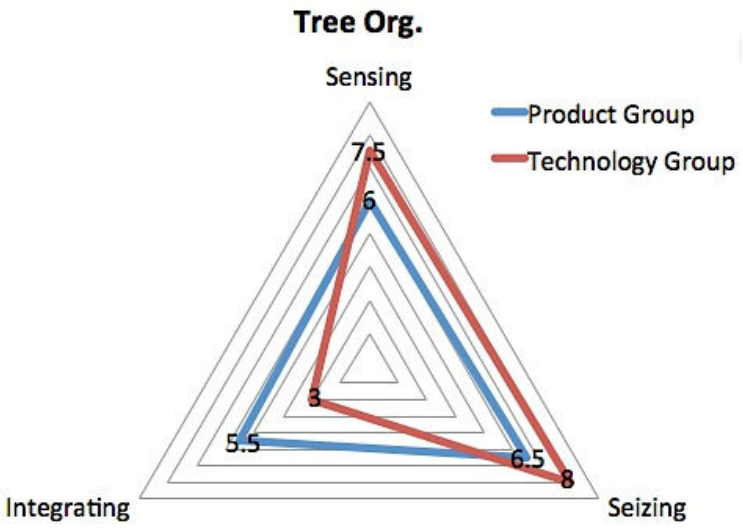


Figure 20: Tree Org. participant OI footprint

Tree Org. Product Group			
	Sensing	Seizing	Integrating
Design Engineer	6	7	4
Graduate Engineer	6	6	7
Total	**12**	**13**	**11**
Average	**6**	**6.5**	**5.5**
Tree Org. Technology Group			
	Sensing	Seizing	Integrating
Lead Research Engineer	6	7	5
Research Associate	9	9	1
Total	**15**	**16**	**6**
Average	**7.5**	**8**	**3**

Table 20: Tree Org. participant maturity assessment

6.2.2 Analysis of open innovation maturity assessment

The challenging aspect of scoring Tree Org. is that certain parts of the business are more mature to open innovation than others i.e. the Optoelectronics Group mentioned open innovation in an internal document, and actively look outside of oil and gas for knowledge (aerospace, power generation, telecoms), but this is not something the Product Group would do, and instead communicate with their suppliers and customers. The company also does not communicate open innovation as a high level corporate message.

Tree Org. has similarities with other oil and gas firms in respect that new developments are largely driven by customer specification, which means listening, communicating, and working with them to find a solution. In addition, Tree Org. stated suppliers as being a source of knowledge. Interestingly, there is a spread

across the firms in terms of location for sourcing knowledge. For instance, Tree Org.'s approach to sourcing ideas is a matter of human resources and employment. Not only will the Technology Group look outside their operating industry for ideas, but as a company, instead of there being a 'search activity', their focus is more driven towards employing individuals from varying industrial backgrounds to achieve an internal capability.

Despite the Optoelectronics Group within Tree Org. searching externally for technology, this was noted as being an ad-hoc activity with no defined process. To help improve the flow of knowledge exchange, Tree Org. has online systems for collaboration. However, this is predominately for internal knowledge sharing. Secondary data collection shows that Statoil, Shell, and General Electric (GE) have online interfaces allowing external individuals to submit solutions/ideas to technical problems the firm is experiencing. From this, an internal panel of experts evaluate the ideas submitted to these firms. In addition, ideas submitted to Tree Org.'s internal system for new products is evaluated across several commercial factors.

The Optoelectronics Group expressed that it is the responsibility of everyone to identify technology. There does not appear to be specifically designated roles for searching; it is just a regular task for members of the Optoelectronics Group. Having said that, a Research Engineer mentioned that it was the Lead Research Engineer who would be in charge of sourcing external ideas when questioned about Technological Gatekeepers. Additionally, the Vice President of Technology confirmed that the Manager of Advanced Technologies is tasked with looking at disruptive technologies, attending trade shows in industries outside of oil and gas. Overall, the firm appears to have high awareness for the benefits of visiting trade shows, conferences and universities to identify technologies. These technologies may not necessarily be in oil and gas, but they are constantly thinking about how they could be applied there.

At the outset, it was anticipated that not many firms would have performance metrics to monitor the value of open innovation activities. Accordingly, this was evident within Tree Org. Nevertheless, the firm did use milestones to assess the progress of their R&D partnership with a university, and they also performed measures on patent outputs. A key feature of the innovation process within Tree Org. is the Stage-Gate-Process whereby there will be a review after each tollgate. In addition, Tree Org. utilise a scoring system to rate new product proposals from the Technology Innovation Arena. Upon total reflection of the data gathered, the table below attempts to provide an unbiased view of Tree Org.'s open innovation maturity. These ratings are based on the closeness of the evidence gathered to the content of the maturity models.

	Sensing		Seizing		Transforming
Innovation environment	4	Innovation environment	5	Innovation environment	4
Business processes	3	Business processes	4	Business processes	4
Individual roles	6	Individual roles	5	Individual roles	4
Performance measurement	2	Performance measurement	2	Performance measurement	5
Average	3.75	Average	4	Average	4.5

Table 21: Analysed Tree Org. OI maturity

The assigned maturity ratings above for sensing is driven by the realisation that external searching is fundamentally an ad-hoc activity. Despite one group looking in other industries for inspiration, there is no defined roles or methods for doing so. Internal measurement systems are also used for advancing or killing internal project ideas. Additionally, due to mixed feedback regarding the success of modes of open innovation used by the business, coupled with an innovation strategy that does not address open innovation, the firm is best described as a dual-orientated analyser i.e. chooses when and whom they will be open with.

6.2.3 Concluding case remarks

The case of Tree Org. was an attractive company to explore for trying to understand how companies engage in open innovation. The lure of Tree Org. was that they were currently involved in a number of business activities associated with open innovation, and was so deemed a suitable candidate for further investigation. During the course of this research, Tree Org. has been involved in joint university/industry R&D programmes, Knowledge Transfer Partnerships, as well as exploring industries outside of oil and gas for technology to aid their own technology portfolio. Yet despite this, it is possible to conclude that the firm has not strategically adopted open innovation, and by association, they are also not involved in open innovation. This research finds that although Tree Org. have leveraged some of the activities associated with open innovation to their advantage, this does not automatically mean they have suddenly altered their approach to innovation. In fact, the existence of the term 'open innovation' has made no impact on the company's decision to pursue these 'activities of open innovation' (joint R&D programmes and KTPs). As Huizingh (2011) noted, open innovation is a blanket term for a range of business activities. A company's decision to get involved in partnerships should not automatically mean they are labelled as being involved in open innovation. Open innovation requires communication, a change in mind-set, and a clear strategy for pursuing it. From the data gathered at Tree Org., there is no such evidence to support this. Therefore, it can be concluded with confidence that this company operates with varying degrees of openness, but they are not doing open innovation. Moreover, this company has shown to be successful without adopting open innovation as an operating model. Finally, the data also shows that participants are over-estimating

their maturity for sensing, seizing, and transforming activities. Reasons for this are highlighted at the end of section 7.4.

6.3 Pipeline Co.

6.3.1 Participant maturity assessment

Similar to Tree Org., the radar chart below is the workshop participants representation of open innovation maturity for sensing, seizing, and transforming activities within Pipeline Co.

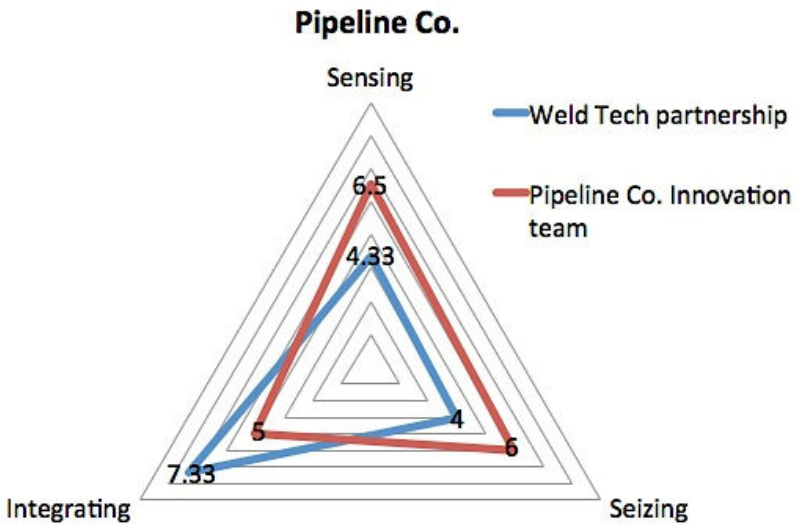


Figure 21: Pipeline Co. participant OI footprint

Pipeline Co. and Weld Tech partnership			
	Sensing	Seizing	Integrating
Managing Director	4	4	7
Commercial Manager	6	5	8
Technical Manager	3	3	7
Total	13	12	22
Average	**4.33**	**4**	**7.33**
Pipeline Co. Innovation Team			
	Sensing	Seizing	Integrating
Technology Manager	6	7	5
R&D Manager	7	5	5
Total	13	12	10
Average	**6.5**	**6**	**5**

Table 22: Pipeline Co. participant maturity assessment

6.3.2 Analysis of open innovation maturity assessment

In 2009, the perception of the interviewees was that Pipeline Co. encountered a problem (technology gap), whereby there was a realisation that people were trying to make out-of-date solutions work i.e. there was a lack of internal technological capability. In order to find a solution fast, Pipeline Co. opted to move for a technical partnership. This would reduce the costs of R&D, and enable them access to proven welding capability. The technical partnership between Pipeline Co. and Weld Tech worked because of the mutual benefits endowed to both parties. Pipeline Co. needed technical welding capability and operated in the offshore oil and gas industry, while Weld Tech had that desired welding capability but had no existing business in the subsea oil and gas industry; Pipeline Co. would be able to provide them with that route to market. An agreement of a 5-year technical partnership was established between the firms.

At Pipeline Co., the fundamental issue for introducing new products is commercialisation. On the whole, new developments are largely driven by customer specification, which means listening, communicating, and working with them to find a solution. In addition, interviewees expressed suppliers as being a valuable source of information. For the cases studied during this research, the technical partnership between Pipeline Co. and Weld Tech was ultimately a commercial success. However, in terms of open innovation there are several issues to consider. First, there is the issue of organisational culture and expected behaviours conducive to open innovation. In order for open innovation to be successful, there needs to be a high level of understanding with regards to the complimentary nature that external knowledge can bring to supplement internal developments. This ultimately requires communicating this vision from the top down, educating employees throughout the organisation about the merits of such a scenario. The data collected from this research indicates that communication about the benefits of a technical partner and how that partnership would work in practice became an internal issue with conflicting opinions. Therefore, to avoid future resistance, Pipeline Co. may consider exploring their innovation strategy in order to better understand the company's position on innovation.

As mentioned already, the technical partnership was commercially successful because Pipeline Co. were able to fill a technical gap, and at the same time, provide Weld Tech with an attractive route to the offshore oil and gas market. Moreover, in terms of the integration phase, very rarely were Pipeline Co. unable to resolve issues with Weld Tech, and problems could be solved over a simple telephone call or e-mail. The issue facing Pipeline Co. now is how to continue the relationship and develop new technology. There is a realisation from within Pipeline Co. that Weld Tech are not going to come to them with their best technology, knowing that Pipeline Co. will try to restrict their ability to deploy it. Perhaps the future scenario will be a matter of procurement, whereby Pipeline Co. will simply purchase useful technology from Weld Tech, or alternatively Pipeline Co. could improve their external searching processes and find a company to replace Weld Tech.

Specifically looking at the Weld Tech case, it was apparent that the idea for a technical partner came from the Managing Director who saw this situation working well in motorsport and thought that Pipeline Co. could benefit from adopting a similar approach. Once a number of potential partners were identified they were evaluated using a SWOT analysis. Crucially, the decision to select Weld Tech was a matter of organisational cultural and the fit between both firms. In terms of Pipeline Co. more generally, there are some issues that restrict the possibility for innovation. One major issue is the fact that Pipeline Co. is first and foremost a contract-based company, each project has a lifespan (profit and loss), and therefore there is limited scope for exploring new ways of working. Secondly, there is the issue of structure. There was acknowledgement that this could be an inhibiting factor within the company, and it would be up to an individual with his/her levels of enthusiasm to drive an idea forward, gather support for it, and get the idea more widely circulated. Moreover, another issue is concerned with human resources. An interesting point was made by one of the workshop participants, who said:

> *"Innovation comes out of your people, taking people from different backgrounds. We don't take people from different backgrounds, we take people from pipeline welding."*

Also, addressing the issue of external searching, another comment was made: *"It's not as if we've gone to the car industry to see what we can take on board."*

Mostly all companies studied within this research cited communication and feedback from customers as their biggest source of information. This may predominately be achieved through sales personnel engaging with clients. However, for the purpose of open innovation, the literature points towards having individuals involved in searching for new knowledge or technologies in the external environment. Despite not finding evidence of such a practice at Pipeline Co., the Global Technology Director mentioned that the company seeks to take a broad approach to searching, attending events like OTC to keep up-to-date of the latest technological developments in the industry. He also mentioned that there is also a 'Technology Watch' area on the firm's Share Point system, providing employees with an ability to share knowledge.

Again, it was anticipated that not many firms would have performance metrics to monitor the value of open innovation activities. Accordingly, this was evident within Pipeline Co. Nevertheless, the 'Beta' model provided the Management Team within the firm with a pre-existing structure enabling them to benchmark the progress of the technical partnership with Weld Tech. For some, the use of an already established model greatly assisted in the overall partnership process with Weld Tech. Previously, 'Beta', a small North Sea oil company, wanted to grow their business and was in need of a subsea contractor to help with their expansion – they chose Pipeline Co. In that project, Pipeline Co. could grow as a subsea contractor and would also be seen as somebody who could partner. At the same time, Beta was able to benefit from Pipeline Co.'s capabilities. In the case of the Weld Tech partnership, the roles were completely reversed. Pipeline Co. took the position of Beta (whereby Pipeline Co. needed assistance), and Weld Tech took Pipeline Co.'s position (whereby Weld Tech

could provide that assistance). Therefore, part of the success of this project was that senior management within Pipeline Co. were able to recall on the Beta model and take it into the Weld Tech partnership. Although, there were varying positions of understanding of the model from the beginning.

In terms of the management team who were in charge of putting Weld Tech partnership together, the data collected shows that there was a high level of understanding for this initiative. This level of understanding fell away further down the organisation. Interviewees indicated that there was an unshared understanding of the partnership at the middle and lower ends of the organisational hierarchy both at Weld Tech and Pipeline Co. A workshop participant noted that some people within Pipeline Co. interpreted Weld Tech as a general subcontractor and wanted to control them like any other subcontractor. While, at the other end of the spectrum, some Pipeline Co. employees recognised Weld Tech as their partner, but thought Weld Tech should do all the work. Also, at Weld Tech, some of their employees perceived themselves as a regular subcontractor and had the mind-set that we are not going to do anything we do not want to do. Despite this, at a particular operation in Brazil, there were individuals who worked for Weld Tech, but acted as if they worked for Pipeline Co. Overall, it is clear from the information gathered that there is a definite mixed understanding and vision for this particular partnership.

More generally, Pipeline Co. has formal R&D reporting systems (CRT, cost-time-resource) for technology developments.

The purpose of the table below is to provide an accurate account of Pipeline Co.'s open innovation maturity by comparing the closeness of the OI maturity model to what respondents said happened within the organisation.

	Sensing		**Seizing**		**Transforming**
Innovation environment	4	Innovation environment	5	Innovation environment	4
Business processes	3	Business processes	3	Business processes	4
Individual roles	3	Individual roles	4	Individual roles	4
Performance measurement	1	Performance measurement	1	Performance measurement	4
Average	2.75	Average	3.25	Average	4

Table 23: Analysed Pipeline Co. OI maturity

Pipeline Co.'s sensing score could be regarded as harsh due to the fact that they realised a need to look outside their business. Nevertheless, this is typical of a firm assuming the negative strategic position of 'reactor'. Due to internal reasons, the business suddenly found themselves to be technologically uncompetitive and had to act quickly to find a solution. Perhaps if they were more proactive and sought opportunities and expressed characteristics of an opportunity-seeking prospector this

could have been avoided. Nevertheless, due to management competence rather than defined processes, the partnership was successful and transforming scores reflect an intermediate maturity level.

6.3.3 Concluding case remarks

When Bianchi et al. (2011) published their paper on organisational modes for inbound open innovation this opened the possibility for targeting specific business activities in order to understand more about how firms engage in open innovation. Consequently, when the opportunity arose to conduct an in-depth investigation of a partnership between two global manufacturing organisations there was no hesitation but to accept the invitation. At this moment in time, when the literature and empirical data on open innovation is relatively scarce in comparison to other well-developed fields, a broad approach to enquiry is necessary. By identifying that Pipeline Co. were involved in a technical partnership with Weld Tech, the current literature would conceivably argue that Pipeline Co. were engaged in open innovation. What this thesis contributes to knowledge is that just because an activity of 'open innovation' is observed from the outside, does not necessarily mean that the company is involved in open innovation. For one, Pipeline Co. had decided to enter into a technical partnership with Weld Tech, not because of the existence of the term open innovation, but because they were struggling internally through a lack of welding capability, and they saw a partnership with Weld Tech as a route to success. This case also highlights the serious issue of communication that was lacking. For one, there was inconsistency around the roles of both companies involved in the partnership. In addition, the idea of open innovation did not exist, there was no communication of an open innovation vision within the organisation, and parts of the company had internal resistance towards the collaborating partner – not a scenario one would expect from a company that has adopted open innovation and personnel have a shared understanding for the company's position on innovation. As a result, this thesis argues that Pipeline Co. operate in the realms of openness, but are not engaged in open innovation. Again, it is also found that Pipeline Co. is commercially successful without adopting open innovation as an operating model. The data also shows differences in opinion concerning the firm's maturity. Nevertheless, this emphasises that the firm is not engaged in open innovation, otherwise there might have been greater internal focus placed on defining sensing, seizing, and transforming processes.

6.4 Valve Co.

6.4.1 Participant maturity assessment

In December 2013, a full workshop was conducted with two individuals from Valve Co. who occupied critical roles within the innovation function of the business. The workshop was conducted at the firm's Advanced Research Centre within a university. The discussion meandered between the Engineering Excellence

Committee who would understand the market and products, and identify any problems that needed addressed, to discussions about acquisitions, university R&D programmes, and also ad-hoc opportunities that would arise. In addition, a senior R&D Engineer was also able to provide a perspective on U.S. operations based on his R&D Department and the procedures for innovation that they adhere to. The maturity assessments from the workshops produced the radar charts depicted below.

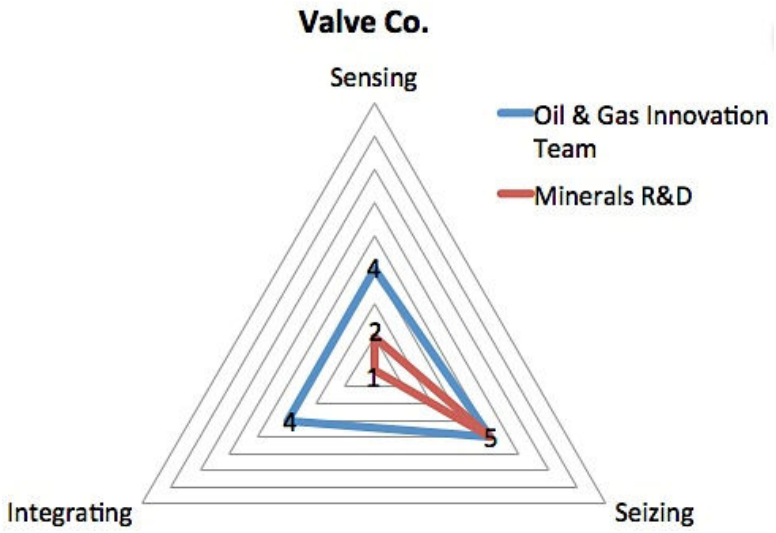


Figure 22: Valve Co. participant OI footprint

Valve Co. Oil & Gas Innovation Team			
	Sensing	Seizing	Integrating
Engineering Excellence Manager	4	5	4
Technology Analyst	4	5	4
Total	8	10	8
Average	**4**	**5**	**4**
Valve Co. Minerals R&D			
	Sensing	Seizing	Integrating
Senior Engineer	2	5	1

Table 24: Valve Co. participant maturity assessment

6.4.2 Analysis of open innovation maturity assessment

Within Valve Co.'s Advanced Research Centre, there is a target to try and select the top 35 projects that would have the biggest commercial impact for the firm. These project proposals are ultimately scored on an Excel spreadsheet through various weighting mechanisms. In order to maintain a consistent balance of technological outputs, the Innovation Team draws upon Kalbach's 'four zones of innovation' diagram, which details the market impact vs technological progress along four types of innovation: incremental, breakthrough, disruptive, and game changing. In terms of

the vision of the company, innovation represents a key strategic pillar that is meant to direct success for the business. However, it was conceded that this lacks detail as it does not come down to the next level to explain what this means. The Engineering Excellence Committee Program Manager claimed that the ideal scenario would be to have a dedicated person come in to Valve Co. to look at their innovation processes. In addition to this, there is a desire to run external technology challenges and establish an internal innovation portal to help integrate the firm's acquired knowledge.

As evidenced by Valve Co.'s acquisition activity, they have strong receptivity to bringing outside knowledge into the business, and also scored high for seizing due to their supportive attitude towards external knowledge. One of the predominant findings from this study with Valve Co. is that new developments are largely driven by customer specification, which means listening, communicating, and working with them to find a solution. This was expressed on numerous occasions and summed up well by a Project Manager who said, *"you can really see that innovation comes from the specifications from Shell."* Another point towards external knowledge is that Valve Co. is more in the mind-set for open innovation, particularly with the idea of launching technology challenges and searching for technology/knowledge. Nevertheless, the concept of open innovation is not incorporated into the firm's strategy. Therefore, having that cultural awareness and employee buy-in will not be so high compared to a company that has spent time on communicating what open innovation is. There is also a feeling that Valve Co. need to address what innovation means to the company so that this can be appropriately managed. Moreover, due to the location where Valve Co.'s products will be applied, the search for new technologies tends not to go beyond a local search within similar operating industries e.g. *"not great going into automotive industry"* – Director Dewatering Systems.

None of the case study companies from this study showed evidence of employing business processes that would assume an advanced state of maturity for open innovation. Valve Co. has a specific process for searching for new technologies and companies through the use of software, but this is not defined or documented. The drive for identifying technologies begins by the Engineering Managers reporting specific problems to the company Directors. The Directors from each of the firm's divisions will then give direction to the Technology Analyst to scout for technologies or companies who may be able to solve the particular problems that Valve Co. have. This process is more based on specific technology and end results, rather than monitoring competition. The programme used is able to screen businesses based on publically available data, and the Technology Analyst is able to filter various categories to see if there are any suitable technologies available. In addition to this, Valve Co. also seeks assistance from universities. Particularly in the Advanced Research Centre, there are numerous research programmes on-going with staff, and this may even involve funding 3 or 4-year PhD research projects. Valve Co. also benefits from collaboration with the university by tapping in to previous research projects and even speaking with experienced academics that hold specialist knowledge.

There is not much to separate the more mature firms in terms of having job roles for looking outside the business. The Technology Analyst that Valve Co. have brought in to a head office role is a company first, and at the outset, it was quoted that this was to help accelerate the innovation agenda within the firm. It was also recognised that the work being done in this role is excellent. There is however no apparent emphasis on the introduction of this role being a strategic move towards open innovation to reflect purposeful internal organisational transformation. Moreover, even with a dedicated searching role, Valve Co. still emphasise the importance of customers driving innovation through their specifications. Similarly, the Sales personnel within Valve Co. contribute significantly towards the front-end of innovation. The Sales team will be tasked with finding out what problems customers are having and reporting this back to Valve Co. so that the R&D teams can make the most informed decisions when it comes to developing new technologies.

A lack of performance metrics to monitor the value of open innovation activities was also evident at Valve Co. Instead, reporting is centred upon patents, and this was evident within the Advanced Research Centre. Also, commercial impact, risk associated, market, and technology readiness levels were all cited as being important areas for the company to monitor.

The table below is to supplement the description of open innovation activity outlined above, and to provide greater accuracy to the maturity assessment by being impartial to the outcome.

	Sensing		**Seizing**		**Transforming**
Innovation environment	4	Innovation environment	7	Innovation environment	4
Business processes	4	Business processes	4	Business processes	4
Individual roles	5	Individual roles	4	Individual roles	4
Performance measurement	4	Performance measurement	2	Performance measurement	4
Average	4.25	Average	4.25	Average	4

Table 25: Analysed Valve Co. OI maturity

In comparison to the other two in-depth cases, Valve Co. has higher open innovation maturity. There are many positives to be taken from this case, particularly considering that they operate in an industry that is well known for slow change. Having said that, due to the firm's activity in other markets, this may help them as they are exposed to other environmental conditions. This firm scores higher in sensing and seizing due to their high acquisition activity, coupled by the fact they have a dedicated resource searching for new technologies and companies with capability that could enhance their offering. The firm does not necessarily score highly for having defined processes, but has been thinking about how technology challenges could provide them with an inflow of ideas and the difficulty associated with managing that process. This firm would also admit that their integration of

companies could be better, as they struggle to know where dispersed knowledge across the business exists. This is why such maturity scores are given for Valve Co.

6.4.3 Concluding case remarks

Like the two previous cases, interest in Valve Co. was centred on their involvement in many forms of open innovation activity, thus providing a suitable platform in which to study open innovation. As already stated, Valve Co. has recently experienced a tremendous period of growth through a series of acquisitions, and according to the literature, an acquisition is evidence of open innovation (Bianchi et al. 2011). In addition, their involvement in university R&D partnerships and PhD sponsorships, coupled with the Engineering Excellence Manager's eagerness to learn more about open innovation became an ideal starting point for the research.

The positive features about Valve Co. in regards to open innovation are that they have a dedicated Technology Analyst who will search the external environment for new technologies. In order to help this process, specialised software is used to filter out potential partnering candidates and technology that may be available. Crucially, the Engineering Excellence Manager confirmed interest in OI (in terms of learning more about it), whereas in the previous two cases, managers never brought up the concept of open innovation. Therefore, one can immediately start to question open innovation as expressed in the literature. Here, there is a manager who wants to know more about open innovation, yet they are involved in acquisitions and university R&D which would lead one to believe that the company is involved in open innovation. However, open innovation is not documented in any part of the company's innovation strategy, nor is it communicated throughout the company. For one, the Technology Analyst is not a reflection of implementing open innovation, the role is simply a reflection of wanting to improve capability in innovation. Therefore, these cases are giving rise to determining what separates open innovation from ordinary acts of business. As a contribution, this thesis would argue that the distinction is based on culture and communication for open innovation, strategy and business processes aligned to open innovation, plus supporting job roles and performance measurement of open innovation activities.

Overall, one could argue that Valve Co. are more consciously aligned towards open innovation because they expressed an interest in it, including wanting to set up an online space for technology challenges. However, the company already successfully introduces high value products to the market without strategically adopting open innovation. The significant contribution here is that Valve Co. is successful without open innovation. Nevertheless, this does not mean that open innovation is not useful. The key to success is continually maintaining and building capability in innovation (Bessant and Tidd, 2008), and taking insight from this research in regards to communication, defining business processes around innovation and monitoring innovation performance can aid in improving the firm's innovative capability. Finally, in terms of reflecting on the Valve Co.'s maturity scores, there is greater honesty in this firm's assessment compared to the other two cases. Their interpretation and subsequent analysis of the data shows that both maturity rankings

are very similar. This does not mean that the firm is poor in innovation; they are simply more accurate when it comes to measuring open innovation performance from an internal perspective and relating what they do as a business in comparison to the maturity models.

6.5 Conclusion

Chapter 6 has presented a case-by-case account of open innovation maturity for three large manufacturing firms operating in the oil and gas industry. These firms were of particular interest due to the fact that all of the interviewees from these cases participated in an innovation workshop and were able to conduct a maturity assessment using the model built in this thesis (see chapter 5). Each firm showed initial evidence of being involved in open innovation activity, and once entry into the organisations was granted, the stage was set to explore how these companies engaged in open innovation. The theoretical frame of dynamic capabilities (Teece, 2007) provided a suitable structure in which to investigate open innovation activity (Lichtenthaler, 2011a), coupled with additional literature material published on open innovation. The data gathered shows that despite the fact that activities of open innovation (industry/university R&D programmes, technical partnerships, acquisitions, and KTPs) were all present, this does not necessarily dictate that the firm(s) is engaged in open innovation. This study shows that these general activities of business can and do occur without the firm actively pursuing open innovation. Indeed, these firms are successful in innovation, even without adopting open innovation as a mode of operation. Consequently, there is a need to stipulate the difference between open innovation and general openness. As will be reiterated in the final concluding chapter of this thesis, the difference between open innovation and openness is based on cultural and behavioural awareness for OI, strategy and communication, specific job roles for OI, defined processes and performance measurement for OI. Many of the other features of business can be reserved for general openness e.g. JVs, acquisitions, searching outside, building relationships, and knowledge transfer. Furthermore, none of these firms communicated that they have an open innovation strategy, however, they could quite easily have been labelled as being involved in open innovation without being involved in such an in-depth study.

Chapter 7. Comparison of open innovation activity in industry

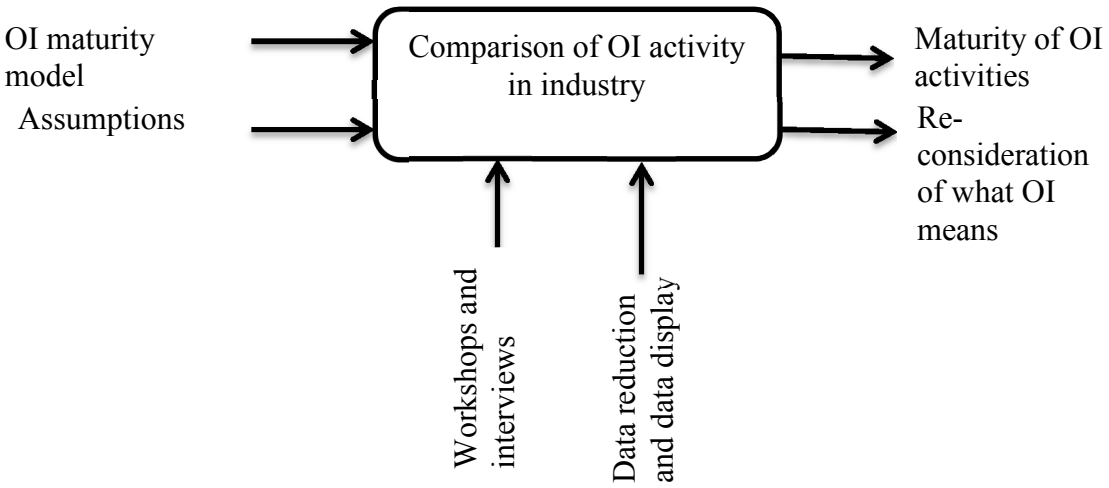


Figure 23: Chapter 7 input - output diagram

7.1 Introduction

The purpose of this chapter is to illuminate how firms engage with and pursue key open innovation activities. A case approach enables a better understanding towards the degree to which firms have embraced the open innovation paradigm, and how the firms structure their operations around it. By doing this, it is possible to gain an appreciation for innovation practices, and in turn, this addresses RQ. 1. *How do firms currently innovate in slow clock-speed sectors?* Using the open innovation maturity model and interview questions, this study investigated the maturity of open innovation activity among ten global energy firms. This chapter presents and compares the maturity of open innovation activity among those firms. Individual company case reports are separately appended to this thesis for confidentiality purposes. Initial findings from this research were presented at the 2014 R&D Management Conference in Stuttgart, Germany (MacKinven et al., 2014a).

This chapter also explores current open innovation practices from coded nodes on NVivo and summary sheets (data reduction). Then, a matrix table is presented, detailing a maturity assessment based on an interpretation of the collected data (data display). The chapter concludes by providing open innovation maturity data gathered from workshop participants.

7.2 Key observations

7.2.1 Innovation environment

Themed as the 'innovation environment', this relates to the firm's innovation culture. More specifically, the task is to explore and gain an understanding for where the firms source their ideas. In a firm that has embraced the open innovation paradigm, one would expect to find that open innovation has been incorporated into the firm's strategy, and employees are aware of the complimentary nature that external technology and knowledge can bring to internal idea generation and development (Dodgson et al., 2006; Huston and Sakkab, 2006; Mortara and Minshall, 2011). There is also an expectation that employees are tuned-in to the mind-set of leveraging external ideas (Katz and Allen, 1982; Burcharth et al., 2014), objectively seeking out external knowledge and technology, and assessing the suitability for any cross-over technology applications (Cohen and Levinthal, 1990; Zahra and George, 2002). Moreover, during the integration phase, there is the expectation that a firm who operates by the open innovation model would have a stable environment for collaboration with externals, whereby knowledge sharing and learning is encouraged between both parties (von Hippel, 1987; Bogers, 2011; Westergren and Holmström, 2012), and the firms work amicably over intellectual property rights (Teece, 1986; Hurmelinna-Laukkanen, 2011).

The only firms that consistently score higher than others for innovation environment is Umbilical Co. and Tech Wellhead Org. Not only do these companies emphasise looking in closely related and unrelated industries for new knowledge and technology (Nelson and Winter, 1982; Bessant and Tidd, 2008; Chiang and Hung, 2010), but also coincidently, these firms both explicitly communicate that they engage in open innovation. They also expressed more receptivity to bringing in outside knowledge (Katz and Allen, 1982), and this is why Valve Co. also scored high for seizing due to their supportive attitude towards external knowledge. Moreover, during the interviews there was a strong sense for commitment between collaborating parties (Rothwell, 1992; Sen and Egelhoff, 2000; McEvily et al., 2003; Asmawi and Mohan, 2011; Bogers, 2011). For example, the Innovation Manager at Umbilical Co. said, *"As an Innovation Manager for the group I have my own definition. When we talk about open innovation we talk about external initiative, it means we are not trying new ideas within our organisation, we go to the outside. Open innovation for us is an innovation initiative involving collaboration with external partners."* Here, it is possible to see that the company has spent effort and thinking towards open innovation and what it means for the company. For this organisation in particular, their focus for OI is on collaboration with SMEs and being more open with their clients and suppliers.

There are a number of factors for the variation in intermediate maturity scores for the other firms. Exploration Co. communicated the term open innovation at a corporate level, but the message fell-out at an engineering level. The other firms did not communicate open innovation at all and this prevents them from attaining a higher maturity ranking, as the paradigm has not been incorporated into strategy. The

challenging aspect of scoring Tree Org. is that certain parts of the business are more mature to open innovation than others i.e. the Optoelectronics Group mentioned open innovation in an internal document, and actively look outside of oil and gas for knowledge (aerospace, power generation, telecoms). A Research Engineer said that they would, *"Take knowledge from aerospace and power generation. Often taking technology that is 5 or 10 years old as it is generally more accepted."* However, this is not something the Product Group would do, and instead communicate with their suppliers and customers (Li and Vanhaverbeke, 2009; Inauen and Schenker-Wicki, 2011). The company also does not communicate open innovation as a high level corporate message. In the case of Integrated Subsea Org. and Pipeline Co. there is evidence of collaboration at the firms, but both are collaborating with partners from similar knowledge domains (Burt, 1992; Nooteboom, 1999; Asheim and Coenen, 2005; Spithoven et al., 2011). Also, there is evidence that Pipeline Co. were fighting resistance to outside knowledge coming into the firm (Katz and Allen, 1982), and this is not what one would expect from an open innovation company. For Offshore Solution Org, there is certainly evidence to suggest that they are embarking on a journey to help employees alter their behaviour to be much more supportive for innovation, but again, no indication of an open innovation message. The Head of Knowledge Management spoke of their development process, *"We spent a lot of time on the tools and the process bit last year, the performance management piece. We still see there are key elements around leadership behaviours and the networking piece that need focus. That's going to be key activities this year, tackling behaviours. Also, how do we better connect our people across the world."*

The similarities between Tree Org, Tech Wellhead Org, Subsea Systems Org, Pipeline Co, Umbilical Co, and Valve Co. is that new developments are largely driven by customer specification, which means listening, communicating, and working with them to find a solution. In addition, Tree Org, Tech Wellhead Org, and Pipeline Co. stated suppliers as being a source of knowledge (Brunswicker and Vanhaverbeke, 2014). Interestingly, there is a spread across the firms in terms of location for sourcing knowledge. For instance, for Tree Org. and Pipeline Co. sourcing ideas is a matter of human resources and employment. Not only will the Technology Group in Tree Org. look outside their operating industry for ideas, but as a company, instead of there being a 'search activity', their focus is more driven towards employing individuals from varying industrial backgrounds to achieve an internal capability. This was confirmed by one of the company's Design Engineers, "O*ur manager sort of highlighted the advantages of a relatively new group is that new people can have fresh ideas, people coming in from different backgrounds."* In contrast, Pipeline Co. will only employ people with experience in pipeline welding. Similar to the Technology Group in Tree Org, Tech Wellhead Org is able to access knowledge outside of oil and gas. For example, their firm is structured in such a way that all their business groups (aviation, power, and healthcare etc.) can source new technologies from their Global R&D Centres. Therefore, what might have been a medical application for their healthcare business can also be used by their oil and gas business. The CEO Subsea Systems at Tech Wellhead Org. explains, *"I may choose to fund a technology programme in somebody else's business truly because it may be a very small segment for them but a very large enabling technology for me. So we have that ability to move stuff around."* For Valve Co., their search activity is not

driven to look at a particular industry. Instead, the focus is on obtaining a specific technology to achieve end results. However, a high percentage of solutions will be from oil and gas. Most importantly, these external activities are complimentary to internal R&D.

Key observations about the innovation environment:

- *Firms seek knowledge from the same knowledge sources irrespective of communicating the term open innovation.*

- *For the firms who communicate open innovation, this message is not being absorbed at an engineering level.*

- *Despite the appearance of open innovation activity, not all firms have transformed themselves to address the NIH syndrome on a company wide basis, communicating the dual benefits of internal and external knowledge.*

- *With or without awareness of the term open innovation, engineers will objectively try to identify technologies at conferences and universities, and try to understand how they could be utilised in their company.*

7.2.2 Business processes

Earlier discussion in this thesis (chapter three, part II, section 3.5.1) argued that firms should have defined processes for key activities (Paulk et al., 1993). Consequently, the workshops and one-to-one interviews attempted to establish whether or not firms who engage in open innovation activity have defined processes for external searching (Laursen and Salter, 2006; MacKinven et al., 2014b), seizing, and integrating activities. The assumption is that if firms operate by the open innovation model, there would be some degree of set procedure or detailed documentation to perform these tasks. Through reading the literature on LEAN, there was an assumption that some firms may have undertaken process-mapping exercises for their core open innovation activities (Slack et al., 2010; Modig and Ahlstrom, 2012).

None of the case study firms showed evidence of employing business processes that would assume an advanced state of maturity for open innovation. For Umbilical Co, they have gone as far to issue a guideline (Paulk et al., 1993), providing tips and actions for engaging with externals i.e. clients and university research labs. Both Umbilical Co. and Tech Wellhead Org. provide time allocation and resource for their employees to innovate. However, Umbilical Co. have time allocation directly reserved for being close to the client, whereas Tech Wellhead Org have time resource for internal R&D. At Tech Wellhead Org, there is clear evidence of a process whereby the CEO of each business will go through a procedure for gaining access to R&D activity from the firm's Global Research Centres. However, correspondence with the Managing Director for the firm's Global Research Centres confirmed that there is indeed no formal structure (Paulk et al., 1993) to oversee or manage open innovation efforts (and this is a message from a firm who communicate

open innovation). Moreover, Valve Co. has a specific process for searching for new technologies and companies through the use of software Dodgson et al., 2006; Van de Vrande et al., 2006), but the process is not defined or documented (Paulk et al., 1993; Winter 2003; Sofka and Grimpe, 2010; Wilhelm and Dolfsma, 2014). The Technology Analyst confirmed that, *"A process for external searching – that's my role, it's not a systematic process. It's just whatever I choose to do is the process."* Similarly, the Technology Manager at Pipeline Co. said, *"I don't think we have defined processes as such. These are things that we do. There is no formal process."* Again, despite the Optoelectronics Group within Tree Org. searching externally for technology, this was noted as being an *"ad-hoc activity",* Lead Research Engineer. Typically, other firms such as Pipeline Co., Hardware Co., Integrated Subsea Org., Exploration Org., Offshore Solution Org., and Subsea Systems Org. will engage with others outside of their business, but there is limited evidence to suggest this is through a systematic process around open innovation.

In terms seizing opportunities, Pipeline Co., Umbilical Co., and Tech Wellhead Org. generally rely on individual judgement about whether or not a technology would be useful for the firm. Also, individuals from Offshore Solution Org., Valve Co., and Umbilical Co. mentioned that any ideas that someone has would generally pass through their Line Manager. However, on more than one occasion, this procedure was cited as being problematic for behavioural reasons. Both Valve Co. and Offshore Solution Org. expressed concerns that Line Managers may not always exhibit the correct behaviours when new ideas are presented to them, and felt that an independent body should be tasked with evaluating proposals. To help improve the flow of knowledge exchange, three firms have online systems for collaboration. However, this is predominately for internal knowledge sharing (Tree Org., Umbilical Co., and Exploration Co). Secondary data collection shows that Statoil, Shell, and General Electric (GE) have online interfaces allowing external individuals to submit solutions/ideas to technical problems the firm is experiencing. From this, an internal panel of experts evaluate the ideas submitted to these firms. In addition, ideas submitted to Tree Org's internal system for new products is evaluated across several commercial factors, reflecting a similar process described in Bessant and Tidd (2008).

For the integration phase, most firms adopt similar processes through defined documentation (Paulk et al., 1993). Contrary to what might be suggested in an open innovation setting, intellectual property is not freely available and openly shared (Hurmelinna-Laukkanen, 2011). For firms such as Umbilical Co. and Tech Wellhead Org. who explicitly communicate open innovation, their stance on IP is that they would seek to find a situation whereby both parties involved could benefit, a method also employed by Pipeline Co. These firms mentioned that if a company came to them with a technology that has potential to be applied in multiple industries, they would only insist on obtaining exclusivity for the oil and gas space, and would not restrict their ability to deploy it elsewhere. However, Tech Wellhead Org. suggested that the ideal scenario would be that they owned the IP or bought the company outright to avoid potential legal issues. This thinking about owning IP is also shared by Tree Org. Their decision to partner with a particular university in an R&D contract was primarily driven by the university's open position on IP ownership.

Predominately, knowledge sharing will only occur following legally signed documentation (Teece, 1986). In terms of the intensity of knowledge transfer during a formal partnership, this can vary from case to case. For example, Pipeline Co.'s technical partner insisted on training Pipeline Co.'s workforce on the new welding techniques. Also, during a trip to Brazil, Pipeline Co.'s Managing Director was unable to separate Pipeline Co. workers from Weld Tech workers, thus showing a high measure of integration. Having said that, as the partnership has matured, the Management Team at Pipeline Co. sense that Weld Tech are no longer going to come to them with their best technology since the company now holds a position in the offshore oil and gas market.

Another issue related to integration maturity was found at Tree Org. One individual expressed dissatisfaction regarding the structure of the partnership, and mentioned that not all of the R&D projects were clearly defined from the beginning. There was also a feeling that not everybody within the group wanted the partnership after the managers and consultants set it up (Barney and Hansen, 1994; Zaheer et al., 1998; Bogers, 2011; West and Bogers, 2014). Even although milestones were agreed, and supervisors were allocated, the difference in success between Tree Org.'s partnership and Pipeline Co.'s was that Pipeline Co. was able to deliver a commercial outcome as they were installing a proven technology. Consequently, the initial internal resistance towards external technology was overshadowed by this positive end result. In contrast, despite Tree Org. having internal resistance to the research partnership, the partnership was not as successful because the team were unable to deliver a commercial product. For a final remark on knowledge integration, Valve Co. has experienced considerable growth in recent years through a number of acquisitions (Bianchi et al., 2011). Consequently, both Valve Co. and Offshore Solution Org. expressed the need for their respective firms to leverage and co-ordinate global knowledge more effectively under an internal system.

Key observations about business processes for open innovation:

- *From the outside looking in, there is observed open innovation activity (R&D partnerships, technical partnerships, acquisitions, and collaboration with suppliers and clients etc.). However, once inside the organisation, the empirical data points towards lack of managed open innovation processes, especially for external searching.*

- *Despite the external appearance of open innovation, firms have not undergone an internal transformation to suggest they are adopting the paradigm as the firm's modus operandi.*

- *For organising collaborative projects, there needs to be a shared understanding about the benefits that the collaboration will bring to the company from the outset. Therefore, communication is seen as vital.*

7.2.3 Individual roles

Prominent work within the innovation literature refers to Innovation Champions (Schön, 1963; Chakrabarti, 1974) and Technological Gatekeepers (Allen and Cohen, 1969). The open innovation literature references the idea of Technology Scouts (Wolff, 1992; Dodgson et al., 2006; Chiaroni et al., 2010; Rohrbeck, 2010; Whelan et al., 2011). In this situation, the role of the Technology Scout is to search the external environment for new technology or knowledge. An assumption held before gathering data was that there would be evidence of such a role in an organisation. Additionally, in a professionalised open innovation environment (Gassmann et al., 2010), one may also expect there to be dedicated roles for seizing and integrating external knowledge and technology into the firm (Tushman, 1977; Asakawa et al., 2010).

There is not much to separate the more mature firms in terms of having job roles for looking outside their business (Umbilical Co, Tree Org, Tech Wellhead Org, and Valve Co.). Both the Optoelectronics Group within Tree Org. and Tech Wellhead Org. expressed that it is the responsibility of everyone to identify technology. There is however a point to note despite this assertion – the common factor towards external searching is that it is Technology Groups who are predominately tasked with this activity. For instance, both Pipeline Co. and Tech Wellhead Org mentioned that it is not possible to drift off and look at new ideas in a contract situation. However, Tech Wellhead Org do make time for one particular group to look, not at the technology, but at the space the business is involved in. Another group will then be tasked with looking externally around technology in the industry, reporting back to the CEO Subsea Systems (dynamic capability). There does not appear to be specifically designated roles for searching at Tree Org (Rohrbeck, 2010; Chiaroni et al., 2010), it is just a regular task for members of the Optoelectronics Group. Having said that, a Research Associate mentioned that it was the Lead Research Engineer who would be in charge of sourcing external ideas when questioned about Technological Gatekeepers (Allen and Cohen, 1969). Additionally, the Vice President of Technology confirmed that the Manager of Advanced Technologies is tasked with looking at disruptive technologies, attending trade shows in industries outside of oil and gas (Teece, 2007; Bessant and Tidd, 2008).

A Senior Engineer from Exploration Co. mentioned that he, *"Would keep aware of what is happening at Technology Conferences (like Subsea Expo)",* but highlighted that this was not part of his job role. Moreover, he also confirmed that if he came up with something innovative he would not know where to go (Whelan et al., 2011). Keeping abreast of technological developments at conferences is also a feature employed by Tree Org. and Tech Wellhead Org. On a note towards absorptive capacity, Tree Org., Umbilical Co. Tech Wellhead Org., and Shell appear to have high awareness for the benefits of visiting trade shows, conferences and universities to identify technologies (Cohen and Levinthal, 1990). These technologies may not necessarily be in oil and gas, but they are constantly thinking about how they could be applied there. The CEO Subsea Systems at Tech Wellhead Org noted that his Product Management Team would typically walk him around everything at conferences such as the Offshore Technology Conference, highlighting

companies that they should speak to, what technologies they might need to consider, or if there is an interesting application that might come through in the future. Therefore, one can see that this is simply an activity employed by the company to keep up-to-date with current technologies, not necessarily with specific job roles for external searching. Interestingly, the Managing Director for their Global Research Centres asserted that he would be, "*Surprised if there were any jobs dedicated to open innovation."*

In contrast, Umbilical Co. and Valve Co. show evidence of dedicated job roles for external searching (Rohrbeck, 2010). The Innovation and Partnerships R&D Manager at Umbilical Co. specifically mentioned that the firm has Regional Technology Officers (RTO) tasked with making contact with clients, pushing novelty in the minds of the client, and also to gather information from the client. He also said that he physically engages in this process in France, while confirming that the R&D Department in Aberdeen regularly meets with academics from UK universities. The RTO's have a relatively small team (5 person maximum) who will work on improving idea generation and transfer of ideas put forward from other sides of the group. He was quoted as saying, *"looking for new technologies is in the R&D people's gene"*. Offshore Solution Org. also has a representative in each global location for putting ideas together. The firm also has a Global Head of Innovation and Knowledge Management actively looking to leverage internal knowledge (Katila and Ahuja, 2002), and seeking out external knowledge when a gap exists internally (Chesbrough, 2003; 2006). However, there does not appear to be dedicated roles for searching externally for ideas. Largely, this will be done by word of mouth (Kawakami et al., 2013) i.e. someone has seen something somewhere that could be used, and the firm will investigate it. A Project Engineer at Umbilical Co also confirmed this type of ad-hoc activity, thus showing both a structured and informal approach to external knowledge sourcing. Similar to Umbilical Co., Valve Co. has a dedicated person for external searching. The firm recently appointed a Technology Analyst to scout for specific external ideas from scratch. This person has been in this particular job for over one year, and it was confirmed that this position did not exist previously.

Overall, and despite companies like Hardware Co. confirming that they do not have a specific department for external searching, mostly all companies cited communication and feedback from their customers as being the biggest source of information (Groth et al., 2004). Therefore, with no evidence of a dedicated external searching role in: Tree Org.'s Product Group, Subsea Systems Org., Integrated Subsea Org., or Pipeline Co. – all these firms still actively sourced knowledge from their customers. Moreover, even firms with dedicated external searching roles (Umbilical Co. and Valve Co.), these firms still emphasised the importance of the customer driving innovation (Johnsen et al., 2006) through their specifications.

For seizing and integrating external knowledge into the firm, Tech Wellhead Org., Tree Org., and Valve Co. utilise their Merger and Acquisitions team if they are to acquire a company. For smaller scale knowledge integration such as R&D or technical partnerships, both Pipeline Co and Tree Org have formal agreements with their partnering institution arranged by Senior Management.

Key observations about individual roles for open innovation:

- *Generally, distant external searching is reserved for individuals within Technology Groups, and less so for Product Groups.*

- *Some Technology Groups will have explicit external searching job roles, while others assume this activity as part of the job.*

- *Most firms will use Account Managers, Sales Managers, and Marketing Managers to talk to clients and feedback what their requirements are (Customer Relationship Management without dedicated searching roles).*

7.2.4 Performance measurement

As innovation is regarded as a significant component to sustained competitive advantage (Teece et al., 1997), measuring it becomes increasingly important. However, as highlighted during the introduction of this thesis, measuring innovation is challenging (Bititci et al., 2012). In addition, Gassmann et al. (2010) indicated that metric systems for capturing the value of open innovation activity have not yet been developed. Despite this, if firms are to truly professionalise open innovation (Gassmann et al., 2010), measurement and analysis of key activities is required (West et al., 2014). Before gathering data, it was anticipated that most firms would not have established performance measurement systems for open innovation. Although, there was the expectation that firms would have measurement systems in place for innovation activities.

As suspected, there is not a high level of performance measurement given to the identified key open innovation activities. For example, Tech Wellhead Org. and Umbilical Co. (firms who communicate open innovation) mentioned that they do not have a measurement around external searching (Gassmann et al., 2010; Antony, 2011). However, Umbilical Co. did confirm that they report on openness (Dahlander and Gann, 2010), which was expressed as, *"The number of possible collaborative projects that have been proposed in the last year"* (Innovation Manager). The firm also asks the Regional Business Unit to report on spending for formalising and capturing new ideas. In addition, secondary data collection around Statoil's external technology challenge shows that the firm collects numerical data on the number of ideas submitted. Following this, each idea is put through an internal evaluation procedure.

In terms of measuring performance of seizing, Tech Wellhead Org asserted that, *"It is tough to put a metric on having to bring in a certain number of externally identified new ideas"* (CEO Subsea Systems). However, for the integration aspect, some firms will be able to employ various tactics to keep track of knowledge coming into the company. For example, Pipeline Co.'s partnership with Weld Tech was monitored using a pre-existing structure from a previous collaboration (Paulk et al,

1993). Therefore, this gave the Technical Manager a structure to benchmark progress against. He said, *"I feel remarkably positive about this one (maturity assessment for transforming). That's because we were able to use the Gamma model. What we had here was a structure in place."* Tree Org. used a milestone approach during their R&D partnership with the university. For Offshore Solution Org., they assess if they have done everything they can to fill a knowledge gap, and then try to determine if they know everything they need to for a given project. For this, they will: (1) identify the current state of knowledge, (2) identify the knowledge that is coming in to give a base-line measure, and (3) re-measure the delta between the two in order to see what value had been added.

By assessing the collected data, it is clear that firms are more mature on performance measurement for the transforming activity. This may largely be down to the fact that this is more project management orientated, and the firms can use traditional milestone and benchmarking assessments. There was also commonality to be found on the features firms would measure for innovation. For instance, Valve Co., Tree Org., and Tech Wellhead Org. perform measures on patents. They also cited commercial impact (Adams et al., 2006), risk associated (Oehmen et al., 2014), and technology readiness levels (Mankins, 1995) as areas they would assess. Pipeline Co. will seek to benchmark against their competitors on a qualitative basis, and utilise cost-benefit metrics to appraise the suitability of technology. A key feature of the innovation process for Tree Org., Umbilical Co. and Valve Co. is the Stage-Gate Process (Cooper, 1990), whereby there will be a review after each tollgate. In addition, Valve Co. and Tree Org. utilise a scoring system to rate new product proposals and will subsequently rank them. For Tech Wellhead Org., one of the most important barometers for innovation is centred on how well their experts know the space they are working in, and how many times they get caught unaware. There is also encouragement for them to engage with other technology groups inside the business.

Key observations about performance measurement for open innovation:

- *Firms are yet to develop or adopt metrics for external searching*

- *Only two open innovation measurements were identified:*

    (1) Basic measurements on the number of ideas submitted to external technology challenges and the evaluation of those ideas
    (2) Reporting on openness i.e. number of potential collaborations proposed in the last year

- *Firms measure technology and innovation in various ways: commercial impact, risk, technology readiness level, patents, benchmarking against competitors, and understanding of their market/technology area*

- *It is potentially more valuable to use all three maturity models developed in this thesis to assess partnerships due to the fact that the 'integration' activity is included. With that said, using the 'sensing' and 'seizing' maturity models*

together can give firms a maturity score for strategic open innovation implementation.

- *Empirical data contrasts to Chiaroni et al. (2010). They argued that two of their case study firms had undergone a profound change in evaluation metrics for open innovation. However, data gathered from this research finds minimal change towards employing open innovation metrics.*

Together, section 6.3.2 (business processes) and section 6.3.4 (performance measurement) has led to realising objective 3: Investigate the processes related to open innovation and how outputs are measured.

In order to provide a visual representation of the empirical data above, a maturity table has been populated based on interpretation of the case data. Maturity ratings are derived through consultation with the content of the deductive-based open innovation maturity model available in the methodology chapter and in reflection of the gathered respondent data. Asterisks in the table denote unavailable data. Individual case reports that were sent to the companies are separately bound and appended to this thesis.

	Pipeline Co.	Umbilical Co.	Valve Co.	Tree Org.	Tech Wellhead Org.	Hardware Co.	Integrated Subsea Org.	Exploration Co.	Offshore Solution Org.	Subsea Systems Org.
External searching maturity										
1. Innovation environment	4	7	4	4	6	3	5	5	5	5
2. Business processes	3	4	4	3	4	3	3	3	3	3
3. Individual roles	3	7	5	6	7	2	4	*	5	3
4. Performance measurement	1	4	4	2	2	*	*	*	4	*
Average	**2.75**	**5.5**	**4.25**	**3.75**	**4.75**				**4.25**	
Seizing maturity										
1. Innovation environment	5	7	7	5	7	5	5	6	4	*
2. Business processes	3	4	4	4	4	*	*	2	4	*
3. Individual roles	4	7	4	5	6	*	*	3	4	*
4. Performance measurement	1	4	2	2	3	*	*	*	*	*
Average	**3.25**	**5.5**	**4.25**	**4**	**5**					
Transforming maturity										
1. Innovation environment	4	7	4	4	6	*	*	*	*	7
2. Business processes	4	5	4	4	5	*	*	*	5	*
3. Individual roles	4	4	4	4	4	*	*	*	*	*
4. Performance measurement	4	4	4	5	4	*	*	*	5	*
Average	**4**	**5**	**4**	**4.5**	**4.75**					

Table 26: Researcher maturity assessment of open innovation activities

By analysing the values attributed to open innovation maturity by the researcher and workshop participants, it is possible to identify a difference in opinion between the two. This gap could have resulted for a number of reasons. To explain this, the researcher may have placed greater significance on:

- Evidence of explicit communication of the term open innovation throughout the organisation
- Incorporation of open innovation into strategy of the firm
- Evidence of the firm directly addressing the NIH syndrome whereby all employees understand the benefits of external knowledge
- Existence of defined and documented processes for external searching, seizing, and integrating activities
- The introduction of dedicated roles for external searching
- Existence of specific internal networks whereby employees can relay identified external opportunities into
- Evidence of a managed process towards open innovation

7.3 Conclusion

As this research seeks to investigate the adoption of open innovation, this chapter has explored and presented the nature of activities associated with open innovation in industry. Through cross-case analysis of ten firms, it was possible to identify a series of key observations related to the extent of open innovation adoption. For structural purposes, these observations are centred on the innovation environment at the firm, business processes, individual roles, and performance measurement activities. Data analysis leads to the observation that firms have not adopted open innovation as a mode of operation. What this means is that from a distance, academics are able to observe open innovation activity occurring in firms. However, once inside the organisation, there is little evidence to suggest that firms have undergone a restructuring or transformational exercise to reflect a managed process towards open innovation. Therefore, the idea of open innovation seems to be a superficial glaze on top of business activities that would have gone on regardless if the term existed or not. Even those who communicate open innovation in external press, show little sign of significant alternative behaviours to those who do not communicate it.

These opinions help to provide insight as to why there is discrepancy amongst maturity ratings between the researcher and the interviewees. For industry participants, the workshops were about how the firm engaged in three innovative orientated activities. However, for the thesis, the research was primarily investigating the extent of open innovation adoption via a managed process. Consequently, the study is now in a position to provide answers to the research questions set in the

research methodology chapter. The next chapter will set out to answers to those questions.

Chapter 8. Discussion

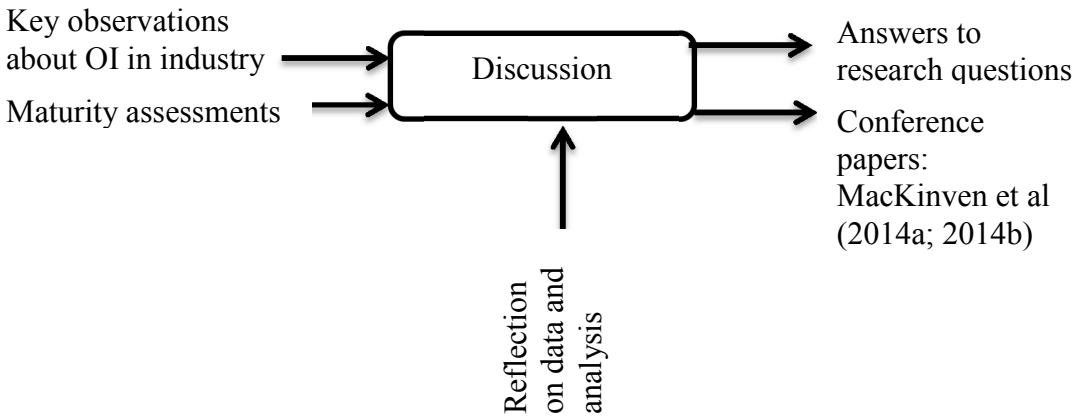


Figure 24: Chapter 8 input - output diagram

8.1 Introduction

The aim of this chapter is to systematically address each of the research questions. Through the process of facilitating innovation workshops and conducting interviews, there has been a gained appreciation for how firms engage in the innovation process. The workshops and interviews provided a suitable foundation upon which to explore three processes related to innovation. As discussions grew, so did understanding about the ways in which firms pursue innovation. The initial and purposefully loosely defined research question provides the ability to highlight the mechanisms and knowledge sources used by firms to improve their business. By further reflecting on the empirical data, this chapter also explores RQ. 2 (*what are the capabilities and processes required for open innovation?*) and RQ. 3 (*what are the factors that affect the strategic implementation of open innovation?*). For firms to become better at open innovation, insight is needed to identify the key areas where firms need to focus on. Moreover, through discussions with interviewees, there is awareness for several barriers that will affect the successful implementation of open innovation in an organisation. As a result, answers to RQ. 3 draw on interpretative skills. The final part of this chapter answers RQ. 4, combining theoretical insights from the literature and information gathered from the research process. In a situation whereby a firm decides to implement open innovation as an operating model, the construct from RQ. 4 provides a model for strategic OI adoption.

8.2 Answers to the research questions

RQ. 1 How do firms currently innovate in slow clock-speed sectors?

As noted in the opening statement of *Innovation and Entrepreneurship* by Bessant and Tidd (2008), it does not take long to realise how important innovation is to businesses. From either speaking to managers or reading company websites,

innovation is repeatedly communicated in value statements and cited as critical to the success of the firm. However, the question remains – how do these firms innovate?

From analysing the empirical data, it is possible to say with high confidence that firms innovate in an open manner. This however, does not mean open innovation. Firms will inherently gather ideas from a variety of knowledge sources (von Hippel, 1988). In the context of this research, the product firms are guided by the requirements set by the operators (Shell, BP, Total, Statoil and Chevron etc.). These firms will dictate the quality standards that each product must reach before they will consider accepting it. The challenge frequently cited by the product development firms is that their clients want the technology, but the difficulty is getting them to buy it. This situation is undoubtedly caused by the risk-averse nature of the industry, due to the potential catastrophic consequences that could ensue from a technical failure. As a result, many product development projects are driven through close consultation with clients, thus confirming their importance as a source of valuable knowledge (Gassmann et al., 2006; Inauen and Schenker-Wicki, 2011). However, at the same time, the product development firms will not sit and wait for the client to request a particular application. These firms are strongly encouraged to innovate, evident by the number of on-going R&D projects within the firms. Therefore, there is an obvious split in terms of development. The product firms will get exposed to the operator's technology roadmaps (Caetano and Amaral, 2011; Lee et al., 2011), while at the same time, they will also have their own market analysts and technical specialists discussing and documenting how they think their space is going to develop over the next five to ten years, overall reflecting similar sentiments shared by Granstrand et al. (1992) on technology scanning. Clearly, there is a gap to fill in terms of satisfying customer needs with proven technology, but also to try and push new technology in the minds of the operators (Rothwell, 1992). This initial discussion provides an insight into one phase of the innovation process. The next area deals with knowledge sources outside of the client.

For a significant proportion of the firms in this study, internal R&D represents a major component of their business operations, as this is considered to be a core competence (Prahalad and Hamel, 1990). All of the product firms confirmed to having dedicated R&D Departments. Within these departments, individuals will be tasked with creating and developing new technologies that will improve safety and efficiency of oil well production. To do this, firms employ highly skilled and highly qualified engineers to meet these technology challenges. Through technology planning exercises and understanding of technology requirements in the oil and gas space, R&D engineers will undertake research activities with the aim of bringing these technologies to market. During this time, engineers will begin to acquire knowledge related to their project from a number of different internal and external sources (Cohen and Levinthal, 1990; Chesbrough, 2003; 2006). For many, the starting point will be to find out if anyone in the company has the required knowledge (Katila and Ahuja, 2002). This often occurs through a layering process. Initially, the problem will be brought to the attention of the immediate team, if no solution is forthcoming, it will then be circulated to the department, and then the department of the whole country. Some firms also have internal discussion boards on their Intranet where individuals can post questions about a specific problem to see if

anybody else in the company has done something similar before. However, not all firms have adopted such a facility.

In a situation whereby there is a knowledge gap internally, the firm will seek assistance from external sources (Chesbrough, 2003). Cases from this study show evidence of knowledge being brought in to the firm through: a technical partnership, company acquisitions, university R&D programmes, Knowledge Transfer Partnerships (KTPs), the creation of a new company by combining expertise from two separate firms, and SME collaborations. Not only do these activities reflect the modes of open innovation discussed in Bianchi et al. (2011), but some activities extend the modes of open innovation e.g. technical partnerships and KTPs. These types of knowledge require higher levels of commitment (Granovetter, 1973; March, 1991) as opposed to other knowledge sources that the firm will leverage i.e. supplier and academic expertise. There are however two other strands to knowledge acquisition that exist. One is related to chance and unplanned knowledge, while the other is related to planned knowledge seeking and uncertain outcomes. For example, interviewees highlighted that on occasions they would become aware of a technology from an e-mail thread, word of mouth, or somebody mentioning that they had listened to a presentation somewhere that they thought was interesting (Kawakami et al., 2013). The other side is through organised conferences (Cohen and Levinthal, 1990) and trade shows where engineers will present their working research, and at the same time, also become exposed to other research projects from competing companies. Research engineers will also attend conferences outside of their operating industry to see how they could benefit from using technology from other areas. Also, some firms have chosen to set-up online spaces for technology challenges, enabling anyone to submit an idea to solve a company's technical problem (Piller and Walcher, 2006; Ili et al., 2010).Consequently, there is an element of uncertain outcomes here, whereby the firm cannot guarantee a consistent flow of potentially useful knowledge.

In terms of structuring the innovation process, many firms choose to adopt a Stage-Gate Process. This model helps firms manage the product development process through a series of tollgates (Cooper, 1990). At each stage, the project is evaluated and a decision is made about whether or not it should proceed to the next gate or be killed (Hart et al., 2003). The stages include:

- Preliminary investigation
- Detailed investigation
- Development
- Testing and validation
- Full production and market launch

From studying the ways in which firms choose to set up their organisation towards innovation, it is possible to see that the product development side is well structured. However, knowledge is not being managed effectively enough to allow individuals from any geographic region access to that knowledge. In effect, there is an issue of interconnectedness whereby the engineers become frustrated. They know that there must be somebody inside the global organisation with the knowledge, but

they have no way of identifying where it is located. There appears to be an opportunity to utilise information technologies to enable employees to connect with one another by introducing a searchable network/database listing all employee core skills and expertise. This would quickly reveal if the knowledge existed inside the firm or not.

On a note towards open innovation, it is evident that the firms in this study do indeed utilise internal and external sources of knowledge (see section 6.3.1). However, as previously mentioned, there is limited evidence to suggest any internal re-organisation or transformation to manage open innovation efforts, even from the firms who communicate the term open innovation. Therefore, it is possible to conclude that firms innovate in an open manner, but have yet to adopt open innovation as a mode of operation. By answering this research question, it is also possible to signal that objective 2 (explore how firms engage in open innovation) has been achieved.

In terms of understanding why some of the investigated companies have contrasting degrees of openness, it is necessary to understand their position within the industry i.e. who is the ultimate customer. The setting of this research (slow clock-speed oil and gas industry), offers a unique opportunity to investigate why some situations prevail and why others do not. Looking at the grand picture of the oil and gas industry, the Operators (BP, Shell, Statoil, Total etc.) are the businesses that control what technologies will be accepted and what technologies will not. A researcher only needs to take reference to the Macondo disaster (Deepwater Horizon) in the Gulf of Mexico and Piper Alpha in the North Sea to understand why such caution is taken. For many businesses in the supply chain, their end customer may not actually be an Operator. In fact, chances are that they will be providing another supplier with a component part that forms part of a larger piece of equipment that will become part of a larger piece of infrastructure to be deployed offshore. Due to a high importance placed on health and safety in the industry, there is a very narrow window of opportunity or tolerance towards changing what is already working.

Lack of environmental pressure (dynamic capabilities) restricts, inhibits, and disincentives firms from changing their practices because it is so difficult to chance the mind-set of the Operators. On the other hand, some Operators are Government backed and encourage more innovation, as well as having more investment in R&D. For example, the Government of Norway is Statoil's largest shareholder and is extremely willing to invest heavily in R&D activity. Consequently, as a supplier who is more open and assumes characteristics of an analyser or prospector (Miles and Snow, 1978), may be more inclined to try novel approaches or innovate if they know their customer is more likely to accept new technologies faster than other Operators who are more focused on cost-efficiencies and defending their market position.

Failure to recognise the current economic situation in the North Sea would be extremely misguided. For the UK Treasury in particular, the North Sea has become of a highly lucrative source of tax generation over the years. Yet, the conditions in the North Sea are vastly different from the days of peak production in 1999 and have been in steady decline ever since, with fewer wells being drilled and lower

production rates. Currently, the North Sea has many stranded pools that at today's cost base are uneconomically viable to extract (Drummond, 2015). With the set up of the Oil & Gas Authority as a result of Sir Ian Wood's recommendations from the Wood Review (2014), and actions of the Oil and Gas UK Technology Leadership Board setting out the technology priorities of the industry (Oil & Gas UK, 2015), no greater emphasis has been placed on lowering the cost base, and maximising collaboration across the supply chain than it has today. In attempt to anchor the supply chain in the North East for the long term and ensure there is a thriving oil and gas industry in Scotland post-production, there is advanced works as part of the Aberdeen City Regional Deal assessing the market demand for creating an Oil and Gas Technology Centre that will focus on pre-competitive co-located R&D collaboration between industry and academia, supported by public and private investment with a focus on the technology export market (Aberdeen City Council, 2015).

These recent examples are meant to emphasise the stark contrast in mentality from the 1980s, 90s to 2015. Once the Brent crude oil price fell below $50 a barrel in 2015 (Raval, 2015), the tone of industry conferences such as Subsea Expo and Offshore Europe were not one of panic, but a stern realisation that change was necessary if the activity in the UKCS were to continue to exist. The previous financial situation of the North Sea meant that there was no incentive to innovate – shareholders were receiving sizeable dividends, and it did not really matter what efficiency level the rig was operating at. However, lower margins, 40 year old structures that are already 20 years past their lifespan, and high maintenance and labour cost base means that the North Sea is no longer operated by large Operators with mass cash resources, but instead by small, lean Operators who must seek out cost efficiencies and better ways of working to ensure profitability. Consequently, as the environmental financial pressures strain on the UKCS, there is a chance that firm strategy going forward will need to take this into consideration. It is not possible to say that either external environment pressures or company strategy is a clear indicator towards a company's decision to be open or closed, but certainly moving forward, changes that have occurred in the external environment is going to have an even larger impact on company strategy as businesses look for ways of making the North Sea a viable and attractive place to work, particularly with more lucrative prospects abroad. There is a chance that more firms will enter the dual-orientated analyser category, with others becoming opportunity seeking prospectors. This is evidenced from the fact that the Oil and Gas Innovation Centre (OGIC) in Aberdeen is currently investigating practices from the aerospace and automotive industries with the aim of bringing key success factors to the oil and gas industry – a key trait of the opportunity seeking prospector (Bader and Enkel, 2014).

RQ. 2 What are the capabilities and processes required for open innovation?

For firms using open innovation as mode of operation to create value, there are a number of capabilities and processes needed for its success. As highlighted during RQ.1, some organisations choose to formalise their product development through a structured Stage-Gate Process (Cooper and Kleinschmidt, 1986) (section 6.3.4). This

thesis argues that if a firm is to gain value from open innovation, it needs to be managed in an appropriate manner also. Consequently, one of the first capabilities needed for open innovation is structural open innovation capability. Aside from online technology challenges (Piller and Walcher, 2006; Ili et al., 2010), which only reflect a small proportion of OI activity, the empirical data showed little sign of a managed process towards open innovation (section 6.4). Therefore, there needs to be a structure in place to accommodate open innovation activity, thus supporting the comment made by Hutter (2014, p. 129) whereby open innovation has 'major implications for structure, processes and distribution of tasks.' Essentially, this confirms that firms may need to adapt their internal organisation in pursuit of an open innovation strategy (Wilhelm and Dolfsma 2014).

For any improvement initiative, there needs to be a suitable environment in order for the improvement works to thrive (Armenakis et al., 1993; Paulk et al., 1993; Hillson, 2003; Bititci, 2007; MacBryde et al., 2012). This concerns senior management understanding of and commitment to the project (Bititci, 2007; Soparnot, 2011; Antony et al., 2012). Consequently, the starting point is reaching a level of understanding amongst senior management about what open innovation means. As noted by MacKinven et al. (2014a), open innovation is a mode of operation, a sentiment shared by Hutter (2014). She also iterated that it is critical for firms to have a firm understanding of open innovation so that appropriate decisions can be made about adopting open innovation as their modus operandi (Hutter, 2014). Firms that decide to pursue open innovation will be required to address a number of issues to reflect this operating model. Adopting open innovation requires a cultural shift in terms of mind-set (Bader et al., 2014), and internal organisational structure. The importance of effective communication (Burnes, 1991; Al-Alawi et al., 2007; Kotter, 2007) at this stage should not be underestimated. Communication is required through multiple channels to ensure open innovation absorption. For one, the adoption of open innovation is required to be incorporated into the firm's strategy, underlying its principles and how the firm will be set up to achieve their goals. The relationship between open innovation and strategy is now being recognised in the literature (Brunswicker, 2011; Bageac et al., 2014), further acknowledged by the forthcoming special issue in Long Range Planning on Open Strategy. The firm is encouraged to organise training sessions so that employees can become knowledgeable and aware of what is involved with open innovation (Burcharth et al., 2014) (section 4.3 RQ. 4). The training and communication should also seek to inform employees of the cultural position towards external knowledge, and addressing the *Not Invented Here* syndrome (Katz and Allen, 1982; Burcharth et al., 2014).

What is striking to note about the companies within this research who mentioned they engage in open innovation and communicate this in their strategy is that two were Tier 1 supply chain companies, and one was a large Operator. Interestingly, all of the other companies could be categorised as Tier 1 supply chain companies as well. Umbilical Co. is a very forward thinking and innovative company, always looking to take technology to the next level. A noteworthy point is that they have also recently formed an alliance with Tree Org, creating a new subsea entity, offering enhanced capability for the Operator business base; a trend that is becoming

increasingly popular. Similarly, Tech Wellhead Org. is also forward thinking and has an ability to pull technologies from other areas of their business into their oil and gas company. Exploration Co. is the sole Operator from this sample to explicitly state they engage in open innovation, however others such as Statoil are also known. Exploration Co's open innovation activity is largely due to investments made with universities. Given the background to slow clock-speed industries, one may find it rather surprising to find evidence of open innovation, even to a degree of it displayed in corporate strategy. However, one must remember that these are competitive, technology-orientated businesses that are not only trying to secure and extend market position, but also develop superior technologies to rival their competitors and add value to their brand reputation. As external environmental pressures increase in the North Sea, it will only exacerbate the need for companies to look at alternative ways of working, and perhaps deal in a hybrid mode of defender and prospector positions (Miles and Snow, 1978).

Other structural supporting mechanisms for open innovation involve the introduction of defined, documented, and managed business processes that relate to core open innovation activities (MacKinven et al., 2014b). For example, instead of external searching being an ad-hoc or undefined activity, managers instil objectivity to this task, encouraging employees to constantly think about how technologies can be re-engineered or incorporated into their business. There is also a need to introduce dedicated open innovation job roles e.g. open innovation champions (Enkel et al., 2011) and managers, and scouts for external searching (Wolff, 1992; Rohrbeck, 2010; Whelan et al., 2011). Firms are also encouraged to devise performance measurement metrics to monitor open innovation activity (Gassmann et al., 2010; West et al., 2014). Such thoughts are driven from the literature based on Lean and Six Sigma process improvement projects. Continuing the discussion on structural open innovation capability, firms could benefit by having a central online hub for open innovation, enabling employees to channel identified opportunities (Scott, 1998; Yang et al., 2010). These properties can be easily summarised in the figure below, moving from the initial learning construct through into strategy development and its antecedents.

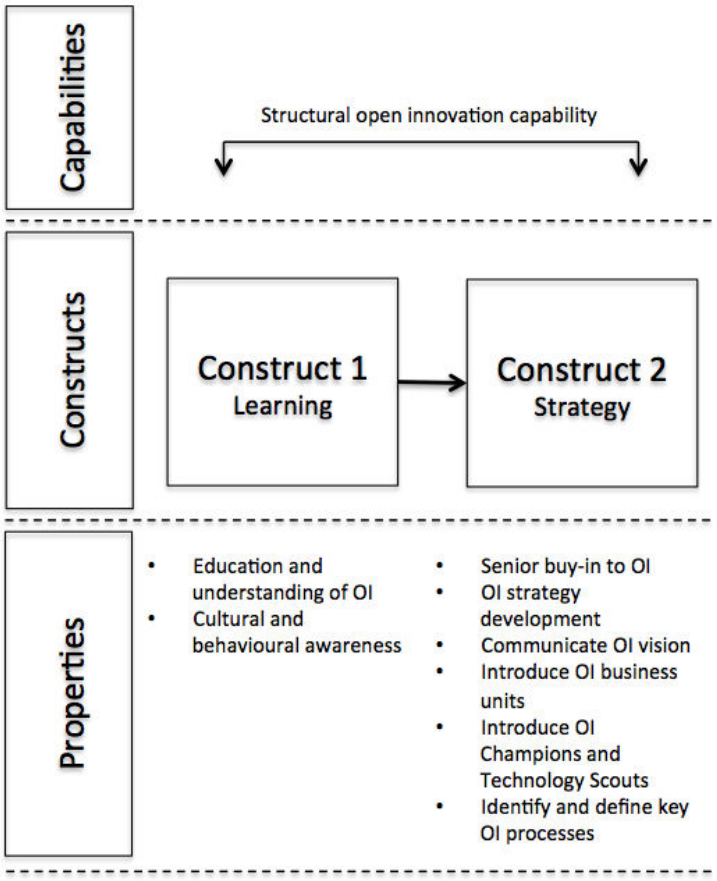


Figure 25: Structural open innovation capability

The second capability required for successful open innovation is knowledge sourcing decision-making capability. This particular capability follows on from structural open innovation capability whereby the firm introduces a clear and structured process towards solving technical problems. In regions of high absorptive capacity and costly R&D investments, firms needs to calibrate the extent to which they use internal vs external knowledge sourcing options (Giarratana and Mariani, 2014). Given that the firms involved in this research have an extensive and highly skilled workforce, the first place to look for expertise would be in-house. Effective internal searching (Katila and Ahuja, 2002) mechanisms would allow firms to make faster, and more informed decisions during the research stage of product development. However, at the present moment, few firms have a resource that enables the engineers to identify where that intellectual resource lies within the company. Should a firm choose to set-up a searchable internal portal that lists the skills and capabilities of its staff worldwide, this would be the first stage in the knowledge sourcing process. Ultimately, implementing open innovation requires the use of knowledge management systems to support its operations (Huston and Sakkab, 2006; Chiaroni et al., 2010). Once this is in place, the firm can begin to engage in a knowledge sourcing exercise.

When a firm reaches a stage and concludes that a specific type of knowledge does not exist inside the organisation, they have to make a decision about how they are

going to obtain that knowledge from an external source. Three potential options include: establishing an online portal for external engagement and publishing technology challenges (Piller and Walcher, 2006; Ili et al., 2010), outsourcing the knowledge acquisition activity to a third party or intermediary (Jeppesen and Lakhani, 2010; Lee et al., 2010; Tran et al., 2011), or being in control of the search activity by implementing various internal processes for external searching (March, 1991; Rohrbeck, 2010; MacKinven et al., 2014b). If a firm were to fully adopt open innovation as a mode of operation, one would suspect that they would be inclined to have an internal resource scouting for external knowledge and technology. Through a structured search process, R&D individuals would be encouraged to identify and attend technology conferences that they feel would benefit the firm in terms of acquiring new knowledge. In addition, attention should be given towards monitoring competitor activities related to technology development. Specifically for the search activity (Laursen and Salter, 2006), firms may benefit from using software to help scan and filter appropriate developments and/or technologies (Huston and Sakkab, 2006). Direction of the search should be split between gathering information from the immediate operating industry and closely related ones, to distant and unrelated industries (Teece, 2007; Bessant and Tidd, 2008). The firm will also need to evaluate any potential acquisition and partnership opportunities that arise as a result of monitoring the external environment. Similar to the section above, these properties are summarised in the figure below.

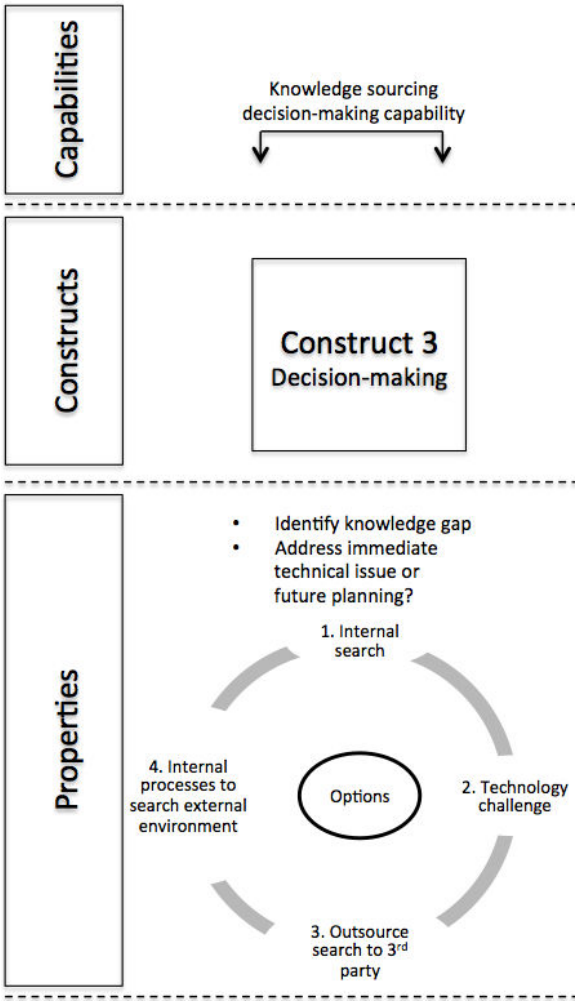


Figure 26: Knowledge sourcing decision-making capability

The evaluation of external knowledge and technology represents a key component of knowledge seizing capability. Once a firm has identified and evaluated a potentially useful external source of information, a certain number of conditions need to be present in the firm. Not only does the firm need to encourage initiative taking (Asmawi and Mohan, 2011), but employees also need to buy-in to the idea of leveraging external knowledge (Katz and Allen, 1982; Dodgson et al., 2006). Also, in terms of internal structures, the seizing process should be formally connected to the knowledge management system. Employees need to be aware of the correct channels to relay information to and from so that appropriate actions can be taken. This may involve the introduction of policies (Paulk et al., 1993) for seizing external technologies so that a level of consistency is achieved. A firm with knowledge seizing capability will be able to successfully capture knowledge that exists outside of the business.

Once seized, the firm needs to make sure that whatever knowledge is being brought into the company is managed appropriately using knowledge integration capability. For firms to benefit from open innovation, the firm needs to have a stable

environment for collaboration with externals (West and Bogers, 2014). Managers need to be able to effectively co-ordinate the seized knowledge with existing internal knowledge. Factors such as commitment, trust, intellectual property, and learning all play a significant role in effective knowledge integration. Again, such properties are summarised below.

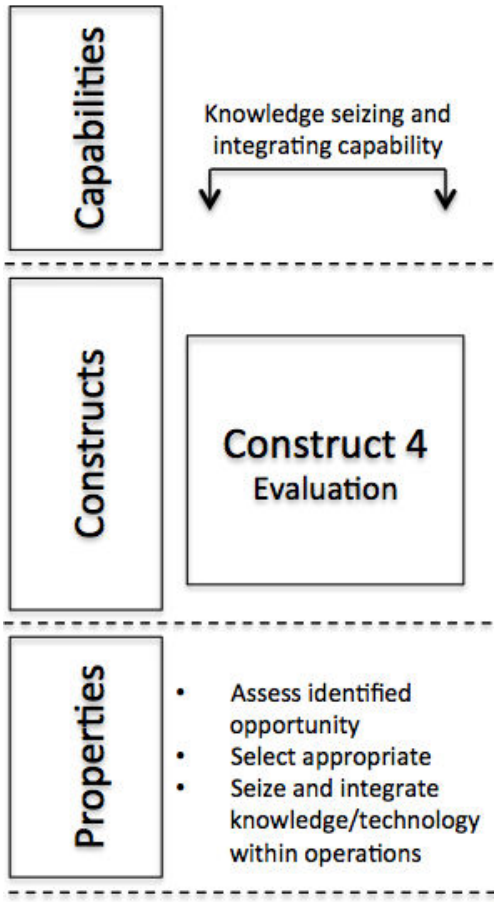


Figure 27: Knowledge seizing and integrating capability

Overall, the capabilities required for successful open innovation include:

- Structural open innovation capability
- Knowledge sourcing decision-making capability
- Knowledge seizing capability
- Knowledge integration capability

In addition, necessary processes include:

- Defined internal and external knowledge searching processes
- Defined knowledge management processes

RQ. 3 What are the factors that affect the strategic implementation of open innovation?

For firms who are interested in professionalising their open innovation activities (Gassmann et al., 2010), having an understanding of influencing factors on open innovation strategy is critical. As open innovation is a business model (Chesbrough, 2003; Badawy, 2011), this thesis recognises that there is a requirement to become familiar with each phase of open innovation strategy. Cross-case analysis of the firms involved in this study reveal several factors affecting the strategic implementation of open innovation. Potential factors include:

- Senior board understanding of its benefits

Individuals in charge of leading the business will have to be knowledgeable about the benefits of implementing open innovation as their operating model and incorporating OI into the firm's strategy. Failure to reach a level of enthusiasm among business leaders may result in difficulty in changing the firm's current business model towards open innovation. Ultimately, business leaders need to be convinced that changing their operations towards an open innovation strategy will improve the business. This thesis finds support for this finding in Hutter (2014, p. 129), who also concluded 'a sound understanding of open innovation and its underlying practices is needed in order to decide if open innovation may be the appropriate modus operandi.'

From the empirical data, it is clear that companies do understand the benefits of collaboration, reflecting the findings in Mortara and Minshall (2011) (specifically in relation to feedback from oil and gas companies). One of the business leaders interviewed during this study mentioned, *"It's really an open environment within where we look and say is there anyone working on this or are there any people who could come together to work on this."* However, when questioned about how open innovation was communicated across the company, he said, *"We'd actually ask the technology/supplier lead from one of the technology innovation groups."* Therefore, perhaps the open innovation message is not being fully absorbed as it could be. Although this company articulates that they are engaged in open innovation, it seems as though this is 'business as usual', and there is no detailed direction towards purposefully managing open innovation. Furthermore, an Engineering Manager from another case firm said, *"I've been trying to push a couple of innovation things within the company and it hasn't really taken off...I think my ideal scenario would have a dedicated person come in to look at our innovation processes…you know, to start running the external innovation challenges, to having the internal portal, and then starting to look at other things."* This insight helps to cement the fact that companies can be involved in open innovation activity, but having open innovation fully adopted into the business requires senior board approval and understanding of the value of open innovation. Linking back to existing theory, Chiaroni et al. (2010) emphasised the role of top management in the change process towards open innovation, echoing previous change literature (Goodman and Dean, 1982).

- Internal resistance

Internal resistance to such an operating model may come from a number of sources. This is potentially best reflected in a hierarchical manner. Possibly, this may be why Chiaroni et al. (2011) stressed the need for supporting roles in open innovation. As already mentioned, leaders need to be convinced that open innovation is more than 'business as usual', providing additional and alternative mechanisms to manage innovation. This statement is mirrored in Hutter (2014, p. 122) where she spoke of the 'considerable internal debates about whether to set up a sustainable pursuit of open innovation.' Additionally, current R&D engineers and managers will need to be persuaded that open innovation can bring benefits not only to the firm, but also to their daily workloads. The R&D function in firms is a critical area, and by introducing open innovation, there is risk that they may feel that their research contributions are being undermined, largely reflecting the NIH Syndrome (Katz and Allen 1982). Chakravarthy and Gargiulo (1998) assert that management should actively promote and experiment with new organisational forms, thus supporting the view that management should be open to the possibility of change. Consequently, the initial learning and understanding period about open innovation can help inform personnel about the expected culture and behaviours associated with open innovation. According to Chiaroni et al. (2011), Italcementi opted for a 'jump-in' approach to create a sense of urgency for change towards OI.

Additionally, as open innovation is concerned with searching for knowledge and technology, a potential major source of resistance may be through the Human Resource Department. For example, if a firm were to introduce a knowledge management system to help improve the ability to search internally for specialised knowledge, this may be met with resistance from the Human Resource Department. The R&D Manager for one of the firms who scored high on the open innovation maturity assessment mentioned that, *"The corporate team were feeling resistance from HR because such a system would cause a dramatic change to the way people search the network."* This change was likened to the introduction of e-mail in the 1970s. He highlighted that, *"A social network is quite a cultural change for a company."* Again, Enkel et al.'s (2011) work on open innovation maturity found that organisations would require a cultural change towards OI. Another type of resistance to such a system may come from the employees themselves. There is every chance that not everyone would wish to be part of a searchable network that lists information related to knowledge backgrounds and skill sets.

In terms of legality, IP Managers and the legal team may be cautious about the firm's new approach to leveraging external technologies in a much more objective way. For instance, if the firm is to engage much more collaboratively or buy licenses from other firms, great attention to detail about restrictions and ownership will be paramount. An Intellectual Property and Innovation Manager confessed that, *"Obviously being a broad base industrial company, it is difficult to say that that technology couldn't be applied to another part of our business. So sometimes it is a little difficult to negotiate those things, for that reason and legal instances, that's why we would always to prefer to have any IP assigned to us."* This result is consistent with previous findings concerning appropriability whereby firms may prefer to have protected IP and ownership (Teece, 1986; Bogers, 2011; Laursen and

Salter, 2014). Also, at a less senior level, shop floor workers may perceive the introduction of external knowledge as a threat to job security. One of the Technical Managers interviewed in this research confirmed that, *"We had people who left over the concept of taking on a third party"* – thus reflecting some negative effects of openness on NPD (Knudsen and Mortensen, 2011). This is why it is so important during the initial phases of open innovation implementation that the company communicates the vision to all employees.

- Firm maturity towards the concept of open innovation

Companies that are more alert to the power of knowledge are more likely to understand why a strategic approach to open innovation may be helpful to accelerate internal research. Burcharth et al. (2014) also relate open innovation adoption to knowledge, and argue that the extent to which open innovation practices are used is influenced by employee attitude towards knowledge. Therefore, firms with a lower ranking open innovation maturity score may be less inclined to introduce this type of operating model compared to a firm with a higher maturity (awareness and open mind-set), reflecting similar comments made by Enkel et al. (2011). This idea of maturity can be closely linked towards organisational culture. If firms are regularly used to changing and promoting new improved ways of working, obtaining employee buy-in will not be as challenging compared to firms who resist change. However, without a clear strategic message as to how the firm will achieve its organisational goals through open innovation, employees may be disengaged in the process. In a final exchange with one of the case study companies about maturity towards OI, the manager said, *"I must say, that with my limited knowledge I would tend to agree with your conclusions."*

This thesis has shown how changing environmental conditions and strategic positioning impact on a firm's openness decisions. Closely aligned to this is the concept of open innovation maturity. While this research has by no means presented a blueprint for companies to follow in terms of improving their open innovation capability, it has described key areas to be aware of that may provide them with some guidance. In addition, it would also be foolish to recommend that the other companies in this sample, or indeed the whole industry to adopt an open innovation approach. Acknowledging that it may be prudent for companies operating in the North Sea to be more co-operative, and as a cost saving measure this seems logical. Again, like Aberdeen's Oil and Gas Innovation Centre's aspirations of creating a super-charged Technology Centre for the industry – there is sense in companies collaborating in the pre-competitive Technology Readiness Level spectrum to accelerate science and learning, and then move back in to company competitive zones where information and knowledge is guarded to be later exploited by that company. There is certainly value in more companies opting for a hybrid 'dual-orientated analyser position' as it means they will make calculated decisions that suit the business at that time on whether to be open or closed in a particular situation. This is extremely important as it means the firm ought to be thinking about when to retain competitive knowledge, and recognising when it makes sense to share information to the benefit of advancing a discipline. Only firms with a certain level

of open innovation maturity will be able to comfortably realise when it is suitable to reveal information and when it is not.

It is conceivable that the process of innovation and technology advancement will speed up as a result of pre-competitive collaboration between industry players. It may also be that this change in speed is too fast for the market if such an approach is adopted. However, it all depends upon what type of industry a Government is trying to achieve. Does a Government want to have an industry that is ranked in the top 5 for technology development, or does it want to let other competitive countries enter the market. If the answer is the former, and that country can be seen to not only develop new technologies at pace, but also deploy them in real-life operating conditions, it can send a strong message to other foreign businesses that this is an attractive place to do business. Therefore, it could be said that there is a vital role for Government strategy in helping to shape the prospects of a slow clock-speed industry.

- Opinions and management issues

An important factor related to introducing an open innovation strategy is its management. Without qualified resource to manage and maintain open innovation activity within the firm, it is likely that it will fail to have a positive impact on organisational performance. See Chiaroni et al. (2010; 2011) for the importance of assigning job specific open innovation roles within the organisation. Open innovation managers will be required to develop appropriate monitoring systems of open innovation activity so that the firm can reach a professional operating level, a process advocated by Gassmann et al. (2010). Therefore, with limited attention given to the operational side of managing open innovation, there is little cause for introducing an OI strategy.

As a final end note to this section on influencing factors, it is important to note its limitations. Firstly, it is conceivable that there could be more factors that impact on the strategic implementation of open innovation. However, based on the research done in this study, it is felt that these were the most obvious. In terms of justifying these claims, there is a need to have a high *corporate level understanding* for such a new initiative, as it will change the way in which the firm operates. This is closely linked to the concept of risk and the ability to weigh up the positives and negatives associated with adopting open innovation as a mode of operation. The claim towards *internal resistance* is largely justified by the fact that people drive organisations and without internal support for change there is a significant chance of failure. Thirdly, *maturity for open innovation* is justified because maturity determines the extent to which a firm is truly immersed in open innovation through strategy or that the firm is simply positioned with varying levels of openness 'business as usual.' Lastly, and potentially one of the most challenging factors for strategically implementing OI is *management issues*. To justify this claim, one needs to understand and comprehend the enormity of being able to manage the influx of ideas and knowledge into the organisation and make positive use of this. Further, there is the added task of defining and organising open innovation processes and monitoring the success of open innovation – (how should this should be done?) These are substantial issues

that need to be thought through prior to implementing open innovation, potentially linking back to the idea of risk.

RQ. 4 What should a model for strategic open innovation adoption include?

The answer to RQ.4 is to be interpreted as a tentative model of strategic OI adoption, grounded from theory. This decision to establish the model from theory helps to improve its validity (Agarwal, 2013; Hamdani et al., 2014). There are three main reasons why developing such a model for open innovation is important:

1. Theory is yet to purposefully expand on Chesbrough's (2003) initial open innovation concept to enable firms to see what open innovation would look like as a managed process.

2. Firms are interested in professionalising their open innovation activities. However, as open innovation is an academic term, industry requires more information about what open innovation actually means before committing resource to it.

3. Due to this limited industrial understanding about what open innovation is, this model can provide managers with a useful starting point to better understand what open innovation may look like in practice.

As the literature is only beginning to recognise the association between open innovation and strategy, the following model is based on content from the open innovation maturity model available in the methodology chapter. The model provides an operationalised view of open innovation.

Within the literature, there is currently a tendency for academics to cite that a company is engaged in open innovation because they can observe them being involved in one or more modes of open innovation (acquisition, partnering, licensing, R&D collaboration etc.). However, these types of activity are conceivably 'business as usual'. The question now must move towards boundary conditions of open innovation. What needs to be done is acknowledge that for a firm to be involved in open innovation, it has to become their operating model, incorporated into their strategy, and managed accordingly. The literature is only now starting to recognise the relationship between open innovation and strategy (Brunswicker, 2011; Bageac et al., 2014; Hettich, 2014; MacKinven et al., 2014a). Therefore, what this model proposes to do is highlight a process perspective of open innovation, albeit conceding that it is not too definitive and additional works are sought to refine it for greater generalisability. The aim is to encourage research in the direction of how firms manage open innovation.

The initial starting point is concerned with change management theory, understanding the facets of open innovation and recognising that it is a mode of operation to be used to leverage value. As indicated in much of the change theory, senior commitment towards the new change programme is essential for success. This

is particularly evident in papers on Lean and Six Sigma (Achanga et al., 2006; Pedersen and Huniche, 2011; Antony et al., 2012). Therefore, given that a move towards open innovation will require great organisational transformation, it is believed that reaching a high level of understanding about open innovation at the outset is a critical stage in the decision-making process. Moving forward, and potentially similar to a traditional innovation process, the firm is required to have senior level buy-in of the new guiding vision for the company. In addition, the formulation and communication of strategy, addressing expected behaviours (Katz and Allen, 1982; West and Bogers, 2014) as well as the introduction of dedicated job roles (Dodgson et al., 2006; Ili et al., 2010; Rohrbeck, 2010) become necessary. Once job roles are introduced, there is an expectation that open innovation can begin to become a professionally managed process through the identification and definition of key open innovation business processes (MacKinven et al., 2014b).

While the firm begins to understand the core open innovation processes, a useful inclusion, particularly for large firms with specialised knowledge dispersed across geographical boundaries, would be the development of a knowledge management system, enabling users to search for internal knowledge across the network. This concept is likened to the theory on internal search by Katila and Ahuja (2002). Once internal processes for open innovation are defined, the firm is in a position to start to begin identifying knowledge gaps within the business, whether they are seeking to address an immediate technical issue or are planning for the future. If no solution is forthcoming from an internal knowledge search, the firm has three primary alternative search options: (1) set-up online technology challenges, (2) outsource technology search to third party/intermediary, or (3) engage internal processes to search the external environment.

Should the firm choose to employ their own external search process (Tripsas and Gavetti, 2000; Sofka and Grimpe, 2010; Li-Ying et al., 2014), there are multiple features to consider. From a business process perspective, one option would be to introduce a defined and systematic approach to external searching. Again, taking insight from the open innovation maturity model, Technology Scouts would be tasked with identifying useful external knowledge and technology, possibly through the use of specialised searching software (Dodgson et al., 2006; MacKinven et al., 2014b). There will be an emphasis on exploratory and exploitive search strategies (March, 1991), leveraging existing networks (Lee and Cavusgil, 2006; Simard and West, 2006), extracting knowledge from suppliers (von Hippel, 1988; Li and Vanhaverbeke, 2009; Schiele, 2010; Brunswicker and Vanhaverbeke, 2014), customers (Gassmann et al., 2006; Inauen and Schenker-Wicki, 2011), users (von Hippel, 1986; Chatterji and Fabrizio, 2013), universities, and research institutes (George et al., 2002; Chesbrough, 2003; Cassiman et al., 2010; Buganza et al., 2011), and attending conferences and networking. This entire process requires management, and if the firm is seeking to reach a professional level of open innovation, they are encouraged to undertake performance-based assessments of the search activity, driving for continuous improvement. The next part of the process, once external knowledge and/or technology has been identified, the firm must then evaluate and select the most appropriate solutions to be seized upon (Bessant and Tidd, 2008). This phase involves contacting the knowledge/technology holder and

negotiating. To improve this seizing process in the future, it could be useful for the firm to gather data to help them understand areas of success and failure in the process.

One of the final stages of the process is concerned with integrating the seized knowledge/technology into the business. An initial question to ask is if project management is required. For example, if a Technology Scout is able to identify a useful technology that the business is interested in, this may simply be a case of purchasing that technology. In contrast, another situation may arise that requires more a more in-depth resource commitment, in the case of a partnership for example. As highlighted in the key observations section, the integration stage is more closely aligned to collaborative arrangements. Therefore, the open innovation maturity model is reflective of such a circumstance. Consequently, at an advanced level of integration maturity, one would expect to see commitment, knowledge sharing (Al-Alawi et al., 2007), learning (Sen and Egelhoff, 2000), trust, and IP resolution between both collaborating parties (West and Bogers, 2014). Additionally, in an effort to improve performance, the firm may choose to undertake a performance measurement based activity of the integration process. The process then repeats itself starting at identifying what the problem area is within the business.

As an output of this research, the practices mentioned above are effectively summarised and modelled in the figure below. This model details the constructs and associated properties for each construct, while incorporating the identified capabilities needed for successful open innovation.

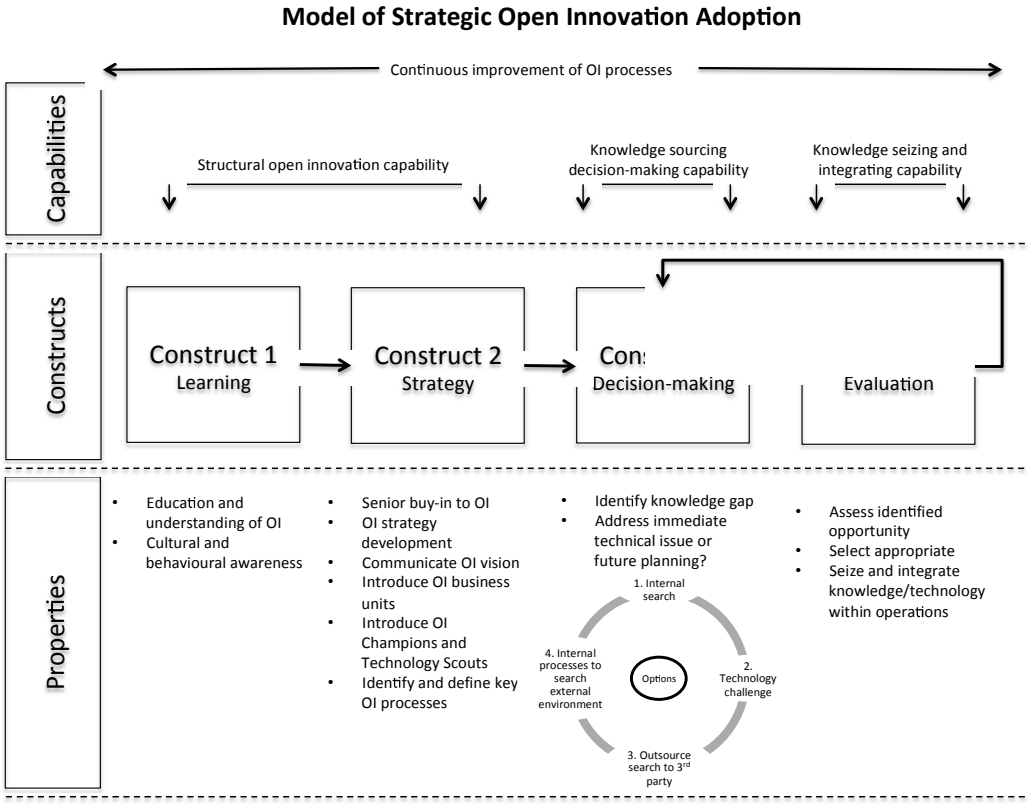


Figure 28: Model of strategic open innovation adoption

8.3 Conclusion

The purpose of this chapter was to draw on and utilise the key observations identified in in the previous chapter to help address the research questions. The first step was to provide an answer to RQ. 1: *How do firms innovate in slow clock-speed sectors?*

Answer: Firms innovate in an open manner, utilising multiple sources of internal and external knowledge during the innovation process. Partnering, acquisitions, recruitment of workers from diverse industrial backgrounds, research centres, joint ventures, and knowledge exchange all contribute to improving the firm's competitive position. Despite some firms communicating open innovation, there is limited evidence to suggest it is a managed process. Crucially, firms are yet to adopt open innovation as a mode of operation. There is also evidence to suggest that external environmental pressures as well as the firm's strategic positioning has a bearing on their openness decisions.

Following this, there was a requirement to answer RQ. 2: *What are the capabilities and processes required for open innovation?*

Answer: Required capabilities include:

- Structural open innovation capability
- Knowledge sourcing decision-making capability
- Knowledge seizing capability
- Knowledge integration capability

Required processes include:

- Defined internal and external knowledge searching processes
- Defined knowledge management processes

Thirdly, several factors affecting the strategic implementation of open innovation are described, providing detail to RQ. 3. This included: senior board understanding of the benefits of open innovation, internal resistance, firm maturity towards the concept of open innovation, and opinions and management issues. Lastly, a solution to RQ. 4 is presented diagrammatically. This final contribution is built in consultation with the content of the open innovation maturity model. The objective of creating this model was to contribute to the call made by Gassmann et al. (2010) concerning the professionalisation of open innovation. Potentially, this model can serve as a discussion point for firms interested in pursuing open innovation, or for firms who simply want to improve their understanding about what open innovation is. The next chapter concludes this thesis, synthesising the main findings and contributions. There is also a note towards research limitations and options for future research.

Chapter 9. Conclusion

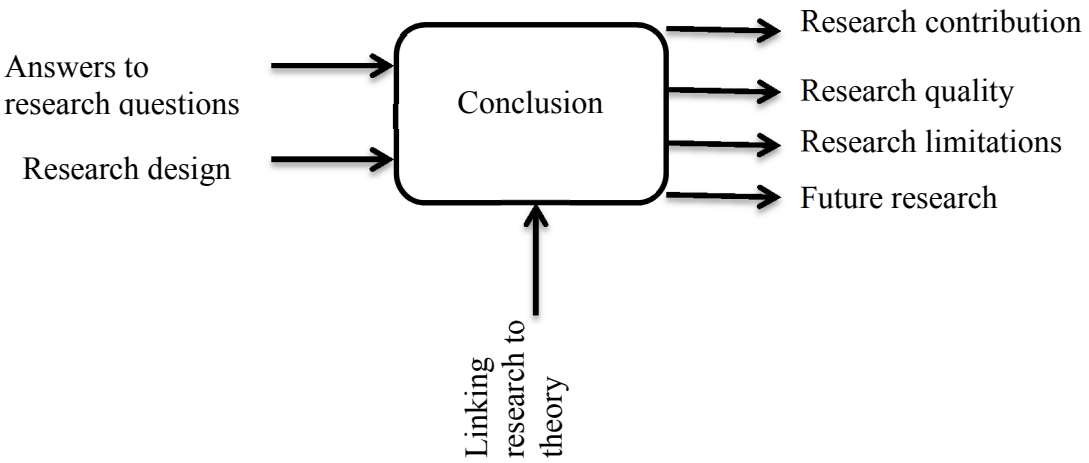


Figure 29: Chapter 9 input - output diagram

9.1 Introduction

This final chapter will mark the conclusion to the thesis, providing a detailed evaluation of its contribution to open innovation research. In doing so, several areas are addressed, including: the significance of analysis, limitations of the work, and suggestions for new areas of investigation. Evidently, the goal of this chapter is to indicate why and how the background theory and focal theory is different due to the research undertaken. The chapter concludes by reflecting on the research experience.

9.2 Open innovation reflections

At the beginning of this research journey, the challenge was to fully understand the concept of open innovation and to identify relevant and associated literature. The main issue of this research is focused on how to become better at open innovation. Therefore, the aim of this thesis was to *understand how the velocity of change in the external business environment impacts firms' strategic open innovation orientation*. In order to realise this aim, several research questions were formulated:

RQ. 1 How do firms currently innovate in slow clock-speed sectors?

RQ. 2 What are the capabilities and processes required for open innovation?

RQ. 3 What are the factors that affect the strategic implementation of open innovation?

RQ. 4 What should a model for strategic open innovation adoption include?

As can be seen from reading these research questions, each question in turn seeks to address the issue of how to become better at open innovation. RQ. 1 attempts to

explore the innovation process in general terms, while focussing on key activities associated with inbound open innovation. RQ. 2 is driven to understand the necessary competences needed for successful open innovation, while RQ. 3 looks to reflect on the empirical data, and offer insights into potential barriers that may inhibit the strategic implementation of open innovation. Finally, RQ. 4 offers a model of strategic open innovation adoption, not only to help managers better understand open innovation, but also to extend open innovation theory by illustrating open innovation as a process.

Reflecting on the literature, it is possible to conclude that the popularity of open innovation is arguably due to its simplicity through composition by packaging an array of business activities and positioning it as a new concept. Since its inception, a significant proportion of papers have been able to show open innovation activity in various contexts (size and industrial) e.g. large firms (Mortara and Minshall, 2011), SMEs (Van de Vrande et al., 2009; Lee et al., 2010; Brunswicker and Vanhaverbeke, 2014), pharmaceuticals (Bianchi et al., 2011), software (Harison and Koski, 2010), and consumer goods (Huston and Sakkab, 2006) to name a few. Also, the dominant trend has been for papers to concentrate on the various practices/modes of open innovation i.e. partnering, acquisitions, licensing agreements etc. (Dahlander and Gann, 2010; Bianchi et al., 2011). Furthermore, because searching for knowledge is an integral activity of open innovation, this area has also attracted attention (Laursen and Salter, 2006; Chen et al., 2011; Garriga et al., 2013; Li-Ying et al., 2014; MacKinven et al., 2014b; Troilo et al., 2014). Overall, case studies have enabled the research community to understand how firms engage in these activities, and what effect they may have on the business.

By developing and using the open innovation maturity model as part of this study, it has been possible to understand how mature firms are in open innovation. The deductive approach to empirical data collection gave a heightened ability to analyse the extent to which firms manage open innovation activity. The analysis of the empirical data has altered understanding about open innovation, and in turn, has resulted in a change in perception of the background theory. The why and how of this change will be expanded upon during the remainder of this chapter. Principally, this thesis focused on the premise that firms want to become better at open innovation, and the aim was to understand how this could be achieved. Now, as a result of this research, it has been possible to bring new insights on open innovation within a slow clock-speed setting. Consequently, it might be possible for industry to gain an improved understanding for the management of open innovation.

9.3 Methodological implications

Naturally, the PhD process provides researchers with a number of challenges to overcome during the course of the study. For this research in particular, the initial challenge was overcoming the fact that open innovation was, and still is, an area of enquiry that is not well developed compared to other aspects of management literature. Additionally, alternative definitions of open innovation are scarce, as are cases of ‘best practice’ organisations. However, upon reflection, the decision to

adopt a deductive approach provided a strong theoretical base to challenge and question how firms engage in open innovation.

In order to analyse open innovation performance, the initial challenge was developing a suitable maturity model. One of the first issues to address was being able to construct a model that could simply investigate activities of innovation, without explicitly mentioning open innovation. There was a perception that excluding the term 'open innovation' from this study was important because it would help to reduce bias in terms of research participation. As open innovation is an amalgamation of regular business activities that occur in organisations, mentioning 'open innovation' is almost incidental. This was achieved by focusing the study on three important innovation activities that happen to be the focus on open innovation.

Another challenge with the maturity model was populating and sorting the necessary content into the model. Initially, the model was only structured around each open innovation activity i.e. sensing, seizing, or integrating. There was a sudden realisation that the content could benefit from improved organisation, and the decision was made to categorise the content according to specific themes. The selected themes include: innovation environment, business processes, individual roles, and performance measurement. Immediately, it became easier for workshop participants to analyse the content of the table and relate their answers to these specific sections, thus providing greater accuracy. However, perhaps one of the most challenging aspects of the research was for the workshop participants to measure performance and place a numerical value on each activity because of the subjective nature of the study. As the purpose of the workshop was to collect data in an engaging manner and communicate the idea of improving innovation processes, the innovation footprint helps to visually highlight current performance and reinforce the concept of improvement.

Although the maturity models were developed with a view to conducting a series of innovation workshops, it was found that the act of engaging and committing companies to a workshop more difficult than initially anticipated. Therefore, although it would have been beneficial to create an environment for debate, not all workshops were able to satisfy this type of resource. As a result, some workshops were limited to single interviews, using the maturity model as a platform for discussion. In addition, by way of gaining additional perspectives about innovation in the case study firms, it was decided to attend industry conferences to interview company representatives. Due to the setting, it was inappropriate to have a conversation looking at the maturity model. Therefore, it was decided to overcome this situation by informally asking questions around the innovation environment within the firm, how they searched for knowledge internally and externally, if there were any specific roles to perform this search, and if any analysis was undertaken on this activity. Through the process of facilitating full and single innovation workshops, telephone interviews, and informal interviews at conferences, it was possible to generate a clear understanding for how firms pursue open innovation.

The following section explores the contributions made as a result of this research, providing additional insight and understanding about the concept of open innovation.

9.4 Contribution 1: Engaging in open innovation

This contribution relates to understanding, through the use of the open innovation maturity model, about how firms in slow-clock speed industries are involved in open innovation activity, and to what extent they have transformed themselves to operate by this innovation model. Data for this study was gathered from firms who communicate that they engage in open innovation and also from firms who do not mention open innovation. Results show that firms are yet to adopt open innovation as an operating model.

9.4.1 Theoretical implications

The field of open innovation research is potentially at risk of having a crisis of identity. Currently, common practice has been to describe an activity of open innovation, whether it be joint R&D contracts, partnering, acquisition activity or licensing agreements, and cite them as being evidence of the firm engaging in open innovation. Given that open innovation does involve these types of business activity, it can be challenging to truly identify what constitutes open innovation and what does not. Yet, one cannot neglect the fact that these activities are simply observed practices of business. Current research has failed to identify how firms have transformed to embrace the open innovation paradigm. As noted by Chesbrough (2003) and Badawy (2011), open innovation is by nature a business model. Yet, the data gathered from this study indicates that there is limited evidence to suggest that there has been any kind of transformation towards open innovation. Perhaps one firm out of the ten case studies showed some indication of movement towards strategic open innovation, but their processes do require further development.

In review of the Strategic Framework proposed by Miles and Snow (1978), it is possible to categorise the extent of open innovation in oil and gas as an example of a slow clock-speed industry. What this research finds is that oil and gas firms are not constrained to innovate, but face a challenge to have their technology accepted by Operators. This is supported by the multiple comments made by interviewees who noted ‘the race to be second’ in the use of new technology. Therefore, due to this natural state in industry of defending market share due to the resistance to deploy new technology, a more closed than open approach to innovation prevails. However, as noted by this research, there are instances when companies will be more open in their activities and seek to bring external knowledge into the business, but the question remains as to what extent this is driven by an open innovation strategy. Consequently, many of the firms in this industry may assume a hybrid position between Defender and Prospector i.e. a dual-orientated analyser - always seeking to maintain a defensive position, but willing to make a quick movement should the right conditions prevail, allowing others to take the initial risk with new technology.

Crucially, the findings from this research help to provide two substantial contributions to knowledge: (1) companies are successful without open innovation. It is not open innovation that is key, but it is the level of maturity towards innovation processes. As noted by Bessant and Tidd (2008, 20), 'firms can and do learn to manage the process for success – by consciously building and developing their 'innovation capability'.' The second major contribution (2) is: there has not been a shift to open innovation as initially claimed by Chesbrough (2003). Not only is there contention around the description of a movement from closed to open innovation, but also, this research finds that companies are yet to purposefully address and manage open innovation efforts.

These findings and contributions were made possible by the development of the open innovation maturity model. Considered as a significant contribution of this thesis, the maturity model gave the necessary theoretical grounding to be able to study open innovation activity in industry. This model contributes to theory by incorporating features of Teece's (2007) dynamic capabilities framework into open innovation literature, but more importantly, its content is built from existing theory and tested in industry. Overall, taking the comments made by Gassmann et al. (2010) about metrics and monitoring activities, the model provides a means to measure open innovation maturity. The use of this model has given the opportunity to understand how firms currently innovate. As a result, it is possible to conclude that firms innovate in an open manner, although there is limited evidence to suggest management of open innovation activity. Reflecting on the open innovation maturity model, it transpires that utilising all three sections of the model (sensing, seizing, and integrating) is useful to assess partnerships. Without assessing the performance of a partnership, the 'sensing and seizing' sections become more useful to assess strategic open innovation adoption. This is possibly due to the fact that the integration phase is more reflective of project management.

9.4.2 Managerial implications

Companies understand the benefits of using external sources of knowledge – they intuitively gather information from various sources on a continual basis. However, the challenge is making that corporate shift towards full implementation of open innovation as a managed process. A significant proportion of resource would be required to address the cultural issues and communicate desired patterns of behaviour (Bader et al., 2014). Moreover, as shown from this study, there is a lack of companies who have shown evidence of transformation to open innovation through having well-defined processes. Therefore, for firms who are interested in pursuing open innovation, there is limited empirical work that could help in formulating an open innovation strategy.

For many, operating by an open innovation model may not be important or deemed necessary. Reinforcing the idea of open innovation as a operating model helps to compound the fact that it needs to be managed appropriately. Given that innovation is recognised as critical to the success of an organisation (Teece et al.,

1997), putting measures in place to manage innovation activity in a professional capacity may provide firms with a better understanding for identifying the most valuable sources of knowledge. On one hand, the open innovation maturity model can assist firms to better understand the features associated with open innovation, but at the other end, it is the firm who is tasked with the job of implementation. A major managerial contribution of this study finds that open innovation is a brand, and companies do not need to do open innovation to be successful.

9.4.3 Limitations

The results of open innovation maturity are largely based on the closeness of empirical data to the content of the maturity model. In order to produce a valid maturity model, consideration was given to background theory on open innovation, and focal theory on strategy, business processes, and performance. The model was created in consultation with other maturity models including, Paulk et al.'s (1993) ProMMM and Enkel et al.'s (2011) open innovation maturity framework. Moreover, as mentioned in the industry comparison chapter, there are some instances where difference in maturity scores between participant and researcher occur. The main limitation of the maturity assessment is not having a higher participation rate during a workshop. This would have given opportunity for debate and greater depth to the assessment. However, from interviews with R&D Engineers and Innovation Managers, coupled with multiple case analysis, a clear picture of open innovation activity is presented. Despite the valuable contribution of these insights, a limiting factor for a proportion of interviews was their duration. In particular, attending the 2014 Offshore Technology Conference gave a great opportunity to talk with senior employees. Yet, due to the unscheduled nature of enquiry and the situational constraint of being bounded by a conference environment, conducting a full open innovation maturity assessment was not possible.

While open innovation involves both the inflow and outflow of knowledge, this thesis has chosen to focus on an area most firms choose to take advantage of (inbound activity). Therefore, while open innovation is recognised for having two main channels for knowledge flow, this research only investigates one of them.

9.4.4 Future research

The development of the open innovation maturity model could be considered as a necessary step towards the professionalisation of open innovation, and indeed performance measurement. An opportunity for future research is directed towards measuring open innovation inputs and outputs. Research is needed to develop indicators to assess the value of open innovation activity i.e. the link between open innovation and performance needs further attention (Du et al., 2014). Such work could involve the use of data analytics software to better manage knowledge for improving operational decision-making. In order for this type of research to be beneficial, it is recommended that these works cross academic and industrial boarders, engaging managers in the process of developing valuable metrics.

Similarly, maintaining the discussion of performance measurement, there could be value in exploring whether or not concepts from Lean or Six Sigma can be incorporated into open innovation for optimisation purposes. Finally, there could also be scope for translating the open innovation maturity model into a survey questionnaire to enable an organisation to run an open innovation diagnostic, giving researchers the option to compare open innovation activity among a wide range of industries.

9.5 Contribution 2: Capabilities and processes for open innovation

This contribution is derived from the analysis of empirical data, whereby it was necessary to identify the necessary capabilities and processes needed for successful open innovation. Results indicate that that there is a need for structural open innovation capability as there needs to be a suitable environment for open innovation to succeed. Additionally, firms need to be able to make the correct decisions for acquiring knowledge. Therefore, this thesis proposes a knowledge sourcing decision-making capability. Moreover, there is also evidence to suggest that firms could benefit from having both knowledge seizing capability and knowledge integration capability. These capabilities will help to improve the chances of successful open innovation.

9.5.1 Theoretical implications

Lichtenthaler and Lichtenthaler (2010) argued that for firms to benefit from open innovation, they need to develop capabilities to deal with inbound activities. By articulating the necessary capabilities, specifically for inbound open innovation, it is now possible to have more concrete picture for where difficulties in the open innovation process may exist. Principally, this research is able to show that the success of open innovation as an adopted mode of operation is fundamentally centred on the ability of the firm to have the correct internal environment for OI. Without due care and attention given to the culture (Bader et al., 2014), surrounding conditions and communication (Katz and Allen, 1982; Al-Alawi et al., 2007; Bititci, 2007; MacBryde et al., 2012), one cannot expect the firm to be in a position to extract maximum benefit from open innovation.

Due to this thesis being heavily weighted towards business processes, and the considerable evidence pointing towards a lack of defined business processes for open innovation, one can assume that firms are in fact not in a professional state of open innovation. While Gassmann et al. (2010) indicated that firms are interested in professionalising their open innovation activities, evidence shows that more has to be done before reaching this aspirational level. In effect, this thesis questions the degree to which companies have adopted open innovation. The capabilities presented in this thesis indicate some immediate areas for thought and organisational development. Through in-depth case analysis, knowledge sourcing decision-making capability has

been identified as a critical aspect of inbound open innovation. This capability builds on the area of internal search noted by Katila and Ahuja (2002), but also considers additional knowledge sourcing options. The inclusion of online technology challenges (Piller and Walcher, 2006; Ili et al., 2010), outsourcing technology identification to a third party (Jeppesen and Lakhani, 2010; Lee et al., 2010), and internal processes for external searching (March, 1991; Rohrbeck, 2010; MacKinven et al., 2014b) all contribute to advancing open innovation theory as it solidifies what options are available to the firm.

Moving on to knowledge seizing capability, the association between absorptive capacity and open innovation is already prevalent within the literature. Findings indicate that firms are generally well informed about technological developments made within their industry and have the capability to identify promising external opportunities. This thesis argues that explicit communication channels and a structured approach to leveraging knowledge will play an important role in the ability of the firm to adequately seize external knowledge and technology. Also, for knowledge integration capability, this is closely linked to structural open innovation capability whereby the success or failure concerning the integration process is largely dependent upon the organisational culture within the firm. As noted by West and Bogers (2014), one of the obstacles associated with integration is culture. Therefore, if a firm is able to cement the principles of open innovation (Chesbrough, 2003) into the minds of employees and have their buy-in (Soparnot, 2011; Antony et al., 2012), this will help to minimise certain difficulties associated with the integration process.

9.5.2 Managerial implications

By identifying the capabilities needed for successful open innovation, managers are now in a position to translate them into processes. As Ray et al. (2004) argued, this can be a catalyst for the firm to realise their full potential. The managerial challenges include defining a structured approach for internal and external knowledge searching. Furthermore, it could be argued that there is a need for knowledge management architecture to enable the effective management of knowledge. Potentially, this could involve the use of software packages to help organise the flow of knowledge in a more meaningful and useful way.

9.5.3 Limitations

This research has been able to identify capabilities that are required for successful open innovation. One issue with this is that there is no guarantee that being aware of such capabilities will translate into successful open innovation implementation. This research simply highlights areas for consideration. Another potential limitation of these results is that they are based on observation, and are therefore bound by subjectivity. Although, the research tactics adopted helped to minimise researcher bias. Due to the fact that this study used the dynamic capabilities framework as a

guide for investigating open innovation, it is not coincidental that the capabilities proposed share similar wording.

9.5.4 Future research

As this study has taken inspiration from the dynamic capabilities literature and translated it for the benefit of advancing open innovation research, further research should seek to investigate the link between dynamic capabilities and open innovation. There is also the added interest of pursuing research concerned with organisational culture and open innovation. Specifically, future research may explore what type of firms (depending on organisational culture diagnostic) (Cameron and Quinn, 2006) are most suited to benefit from adopting open innovation as an operating model. Furthermore, as open innovation theory progresses, it would be interesting to understand how firms adapt their behaviour and practices according to the requirements set for open innovation to be truly beneficial. This type of research is anticipated to require exploration into organisational change theory.

9.6 Contribution 3: Designing a model of strategic open innovation adoption

This final contribution is positioned as a managerial aid for firms to better understand the defining features of open innovation. Also, for those who wish to develop open innovation processes, this strategic open innovation model can serve as a starting point to structure thought and discussion. This model makes an important contribution to the literature because it aligns the phases of strategic open innovation adoption to its constituent capabilities as an integrated system. Consequently, this model offers insight into how aspects of open innovation are connected to one another as a whole.

9.6.1 Theoretical implications

The Model of Strategic Open Innovation Adoption seeks to supplement the earlier *'contribution 1: Engaging in open innovation'*, by communicating open innovation as a visual strategy model. In terms of understanding how open innovation is different to more 'traditional' forms of innovation management, the following section will make those distinctions. Traditional innovation concepts could be directed towards Robert Cooper's Stage-Gate Process (Cooper, 1990) and also Tidd *et al.'s* (2001) 'Managing Innovation' model. For the Stage-Gate Model in particular, it does not specifically reference options for where ideas will be sourced, it simply says both internal and external ideas can be used (Cooper, 2008), nor does it emphasise the importance of an open innovation culture within the business. Moreover, despite the updated Stage-Gate Model (Cooper, 2008) with an open innovation perspective, the strategic open innovation model proposed here (phase 3) provides alternative options for sourcing ideas. Therefore, one can see that phase 3 would be suited at being incorporated at the beginning of the Stage-Gate Process.

Such findings are consistent with Grönlund et al. (2010) who proposed an Open Stage-Gate Model, representing a more dynamic approach to NPD.

For the model developed by Tidd et al. (2001), they explicitly mention strategy, formulating effective external links, and having a supportive organisation. As a result, some may question how open innovation is different to this innovation approach that already exists. For one, open innovation is a mode of operation and emphasises the complimentary nature that external knowledge can have on internal developments. This is first and foremost a key point to differentiate 'traditional' innovation from open innovation, as this phase requires communication and organisational buy-in. Despite firms seeking assistance of others on a regular basis, having that organisational awareness for the company's position on innovation is paramount. Additionally, open innovation provides a structured approach to innovation if incorporated into strategy by outlining the various options for sourcing ideas. There is also greater emphasis on objectively leveraging external knowledge through defined searching processes, as opposed to simply maintaining and building effective external links with universities, research institutes, suppliers, customers, and public bodies. Therefore, although Cooper's (1990; 2008) and Tidd *et al.'s* (2001) innovation models are still important, open innovation is different because it is an operating model for innovation and has external knowledge playing a much more pivotal role in the innovation process. Consequently, due to the potential increased volume of ideas that may be generated, the firm is required to allocate appropriate resource to manage this. As a reflection, there are many similarities to be taken from the three-phase: idea generation, evaluation, and selection process in Bessant and Tidd (2008). However, open innovation presents many more options for gathering ideas, with a purposeful direction towards searching for knowledge.

This Model of Strategic Open Innovation Adoption advances Chesbrough's original open innovation model by trying to understand open innovation as a process. There is much literature associated with open innovation, but it could be considered as fragmented. This model helps to integrate that literature to better understand the steps involved in open innovation and what supporting capabilities are necessary in open innovation.

9.6.2 Managerial implications

Managers are increasingly recognising the importance of innovation to their company's success. As a result, they are interested to learn about the adoption of innovation processes within different organisations and how they compare against them. More specifically, interest in open innovation has increased substantially in recent years, but managers are yet to fully understand how open innovation can be purposefully used in their business. During the special session on *'Operations as Practice: linking OM research and practice'* with Chris Voss, Pietro Micheli, Mark Johnson, Nigel Slack, and Matthias Holweg at the 21st EurOMA Conference in Palermo, Italy, it was stressed that research should seek to address an industrial problem, rather than trying to fill a gap in the literature. Accordingly, this model goes some way to addressing Gassmann et al.'s (2010) claim that firms are interested

in professionalising their open innovation activities, and it is hoped that this model can help to serve as a basis for discussion about what OI may look like in practice. While the empirical data has shown that firms are yet to purposefully set direction towards open innovation through defined processes and management, there is value in this model for managers to better understand open innovation as a process.

9.6.3 Limitations

The model is predominately developed based on current literature and theory as there was difficulty in finding evidence of best practice in open innovation. The contextual nature of the study could perhaps have played a role in this situation, however the research was conducted among high-tech organisations and prior literature suggested that OI was prevalent in such a setting (Chesbrough, 2003; Chesbrough and Crowther, 2006). Additionally, this model is preliminary and should not be considered as definitive.

9.6.4 Future research

Notable follow on works from the development of this tentative open innovation model would involve organising a session to enable managers to provide feedback on the model. If firms are to reach a professional level of open innovation, its users need to be able to fully understand the concept and recognise how certain aspects are connected to one another for the purposes of management. Future research could also involve an action research study, whereby the researcher is involved in the implementation of an open innovation design. This would provide theory with additional knowledge about how companies implement open innovation. A longitudinal study would offer the opportunity to extend theory by becoming aware of the impact a strategic open innovation model has on organisational performance.

9.7 Research quality

In order to be confident that the research undertaken is of sufficient quality, it is necessary to run a series of quality checks. This section will provide a summary to the research design chapter, highlighting the procedures that were performed during this study.

To address the issue of construct validity, multiple sources of data were triangulated. To begin, the first task involved an extensive literature review exploring background theory on open innovation. Once a gap in the open innovation literature was identified, the next step was to formulate ideas about what other theories could assist in answering the research questions. This resulted in reading through strategy, business process, and performance literature. Once this theoretical underpinning was achieved, it was necessary to use existing theory to develop the maturity model. During the data collection phase, workshop participants and interviewees provided information on the core areas of open innovation at the heart of this study. Not only

was data was collected from multiple organisations, enabling a chain of evidence, but it was also retrieved from employees across the organisation's hierarchy. Moreover, for the firms who participated in the workshops, case reports on their open innovation activity were fed back to key contacts within the organisation for review.

To test for internal validity, a pattern matching exercise was performed during the data analysis stage. Internal validity is concerned with determining causal relationships between variables, enabling the possibility to make inferences based on the analysed data. In this study, data was triangulated (Denzin and Lincoln, 2000) from a variety of research participants with the purpose of gaining a clear understanding for the relationship between innovation activities and strategic open innovation adoption.

For confirming external validity (the extent to which findings can be generalised) (Yin, 2003), repetition logic was used across multiple cases. A point to note is that the goal of case study research is to better understand phenomena in the context of where the research is taking place, and not necessarily to make wide generalisations (Stake, 1995). Therefore, as the 10 case study firms involved in this research were from the oil and gas industry, findings can be generalised for this area of business. The use of repetition logic not only allowed understanding for what was happening in practice, but actually forced the issue of re-visiting the existing literature and challenge what open innovation meant, signalling an abductive approach to the research (Dubois and Gadde, 2002; Dubois and Gadde, 2014).

The check for reliability ensures that the research was conducted in a consistent way, and if replicated by another individual, the same results and conclusions would be found (Miles and Huberman, 1994). Yet, due to the subjective nature of qualitative studies, achieving absolute similarity can be difficult. However, to allow the ability for this study to be replicated, a structured approach to data collection was employed through the use of a case study protocol and case study database (Yin, 2003). The use of these tactics ensured that useful data was collected that could eventually be analysed to answer the research questions set.

9.8 Reflections of PhD experience

The following section provides an honest account of the researcher's feelings towards the entire PhD process. First and foremost, this has been one of the most challenging and enjoyable learning and personal development experiences to date. The researcher is also thoroughly grateful to have been accepted to study at the University of Strathclyde. Reflecting on the research process, there is no question that the researcher has benefitted intellectually from the continued reading and analysis that is required for pursing a PhD. Bluntly, the process has been more enjoyable than initially anticipated, or thought possible. The satisfaction of doing research has also confirmed that this would be a desirable career path. There is no feeling of regret about doing the PhD, and if what is known now was known at the beginning of the research process, the researcher would still have pursued the PhD. Having said that, there is a sense that perhaps this research did not comfortably sit

within the researcher's assigned departments (Management Science, and Marketing). Research within the Management Science Department at Strathclyde is predominately centred on topics such as: risk and reliability, simulation, optimisation, and statistical analysis. Other research is associated with decision analysis, knowledge, operations management, and performance measurement and change. Yet, there is a residual feeling that the majority of research interest is skewed towards the Operational Research side of the spectrum. Within the Marketing Department, common themes of research interest among staff include: services marketing, branding, consumer culture and behaviour. As such, when the researcher presented work to an audience from the Department of Strategy and Organisation, and attended their research seminars, there seemed to be a better alignment of research interests.

One of the most positive aspects related to this PhD was the support received from both academic supervisors. Perhaps it is not possible to put in words, but together, they managed to strike the right balance between listening and knowing when and how much advice to give without explicitly telling the researcher what to do. Although difficult at times, this allowed the researcher to improve his critical thinking skills and formulate his own opinions for tackling research problems. Truthfully, the researcher could not have been given better supervisors.

As for the challenge that this PhD brought, there is a sense of arrival and accomplishment – not only academically, but physically. From the initial feelings of doubt prior to starting his MSc in 2010, questioning his ability to make the step up from honours to masters, and then to complete a PhD, there is tremendous satisfaction to be taken from this immense academic journey. As indicated by previous PhD students, the process does indeed require stamina, enthusiasm, commitment, determination, and motivation. Thankfully, because of the enjoyment found from researching, there was very rarely that 'Monday morning feeling'. Nevertheless, three years is a long time for one person to spend on the same project, and continual work is required to make the necessary progress for completing on time.

By the characteristics of a PhD, the requirement is to contribute new knowledge. However, this was not necessarily the initial driver for undertaking the study. For the researcher, it was much more important to find an interesting project that would maintain his interest over the period. As the concept of open innovation stimulated interest, and a positive recommendation was received for the two academic supervisors that would be part of the project, there was little hesitation to proceed with the application. Once the researcher became more engrossed in the study during the data collection and analysis phase, greater significance was placed on making a contribution to knowledge. Not only does the PhD in itself provide this, but also disseminating work via conference presentations became increasingly important for the researcher.

Related to qualitative research is industry engagement. Although a frustration at times, the researcher gained great enjoyment from meeting with company managers and speaking to them about innovation. Without existing industry contracts it is

extremely difficult for an early career researcher to gain access to an organisation. Fortunately, the researcher quickly realised that companies would play an integral role in the success or failure of this research and completion time. Therefore, an on-going task from year one was to contact companies to participate in the research. Even although the researcher understands that there are many PhD students across the university seeking industry engagement, greater assistance from the university to leverage existing contacts would have been helpful.

An area left untouched throughout this thesis is the topic of tutoring. As PhD students of the Business School at Strathclyde University, researchers are given the option to be a tutor on undergraduate modules while working towards their PhD. This opportunity undoubtedly enhanced the researcher's confidence in public speaking. However, after having had the experience of being a tutor for three years, the researcher is confident that his main interest is research.

9.9 Conclusion

This section of the thesis will summarise the key points made during the final chapter. Already recognised as a significant output of this research, the Open Innovation Maturity Model gave the appropriate grounding to investigate how companies engage in open innovation. Also, it provides an ability to measure open innovation maturity. By approaching this research deductively, gathering empirical data, reflecting on it, then questioning existing theory - this overall abductive approach helped to gain a much more thorough understanding for what open innovation is. Moreover, it also offers evidence to show that open innovation is at a stage whereby there is potential for it to have an identity crisis. Not only did the data show companies operating by varying degrees of openness, but even for the firms who communicated open innovation – they did not show substantial evidence of transformation towards OI through culture, processes, individual roles, and performance measurement of key activities. Therefore, this thesis was able to provide evidence to support the fact that environmental pressures have weighted significance in the presence or omission of open innovation strategy. For some firms, many historically assumed a strategic position of defender or analyser, yet due to economic changes in the external environment there may be greater incentive to open up.

This thesis reinforces the fact that open innovation can be used as a mode of operation, and that the strategic orientation of a business will influence their decisions in openness. There is acknowledgement that there is variation in the data collection procedure (workshops and interviews) and time duration. However, due to constraining factors previously highlighted in the research design chapter, best use of the circumstances were made during the course of the study. As a result of empirical collecting data and understanding the literature, it was possible to identify the capabilities and processes required for open innovation; structural OI capability, knowledge sourcing decision-making capability, knowledge seizing and integrating capability, defined internal and external knowledge searching processes, and defined knowledge management processes.

In order to understand how companies can become better at open innovation, the Model of Strategic Open Innovation Adoption has an important role in enabling companies to understand open innovation as a process. Furthermore, this model helps to position open innovation from more traditional forms of innovation e.g. Stage-Gate, Tidd et al.'s (2001) and Bessant and Tidd's (2008) Managing Innovation models. Finally, several areas for future research were identified. Of particular immediate interest is having the Model of Strategic Open Innovation Adoption evaluated by industrial practitioners.

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Appendix 1: Participant information sheet

DEPARTMENT OF MANAGEMENT SCIENCE

University of Strathclyde Business School

Workshop information

Information about the research:
This research is concerned with the issue of: how do we become better at innovation? Gassmann *et al*., (2010) noted that firms are seeking to professionalise their innovation activities. Therefore, this research proposes a means for measuring current innovation performance based on existing literature. The aim is to achieve a better understanding for how firms currently engage in innovation.

Information about the innovation workshop:
The first half of the workshop involves testing a framework that will assess the level of maturity for 3 key innovation activities. Participants will be asked to describe how these activities are carried out and explain why. The second half of the workshop requires participants to develop a process map for each innovation activity.

By participating in this workshop, the project team will receive an innovation footprint, which will visually illustrate the current level they are performing at. Moreover, the maturity tables used in the workshop will offer suggestions as to how innovation performance may be improved. The workshop is also an opportunity to highlight strengths and weaknesses in current processes.

Workshop duration: Approximately between 1 ½ and 2 hours
Workshop requirements: Minimum 5 engineers from the same project team per workshop, 3 workshops in total per company
Workshop location: Company office
Workshop facilitator: Stuart MacKinven

Background information on workshop facilitator:

Stuart is conducting research that will contribute towards his PhD in Management Science. He is currently in his 3rd year of postgraduate study and aims to be completed by October 2014. He is also a tutor within the Business School on modules MS151 Harnessing Technology for Business, and MS204 Organisation and Technological Innovation.

Contact details:

Stuart MacKinven, University of Strathclyde, Department of Management Science, 40 George Street, Graham Hills Building, Glasgow, G1 1QE

E-mail: stuart.mackinven@strath.ac.uk

Appendix 2: Confidentiality sheet

DEPARTMENT OF MANAGEMENT SCIENCE

University of Strathclyde Business School

Consent form for research

I give my permission for Stuart MacKinven to conduct a research project at our office.

I understand that the project is designed to investigate the innovation processes at the company.

I am aware of the purpose of the project and participants are taking part voluntarily.

I understand that participants can withdraw from the research at any time.

I understand that the name of the company and other personal information that may identify individuals will not be used.

I give my permission for the data to be used in the process of submitting work for future publications.

I authorise Stuart MacKinven to conduct workshops with our employees.

I give my permission for workshops to be recorded.

_____ Signature

_____ Printed Name

_____ Job title

_____ Date

Appendix 3: Case study protocol

Open Innovation Research Project

Case Study Protocol

July 2013

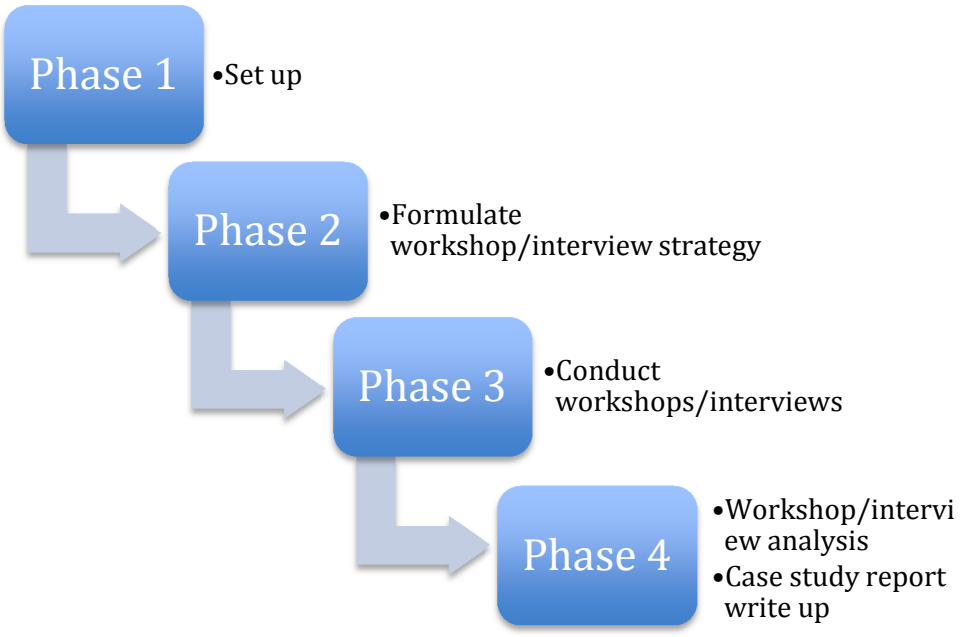
Overview

The aim of the research project is to gain an understanding for how firms have strategically adopted open innovation as strategy. The project aims to firstly measure open innovation performance levels within a cross section of energy firms. Following this, the output of the research will be to identify the capabilities and processes required for open innovation, as well as the barriers to its strategic implementation. Additionally, the research aims to put forth a tentative model for the strategic adoption of open innovation, detailing open innovation as a process.

Data will be collected through a series of innovation workshops and interviews with case study companies. Each workshop is focused on a specific project team, with the aim of (1) measuring open innovation performance, and (2) mapping current processes performed. The workshops will ultimately reveal the current state of open innovation in practice.

The purpose of the Case Study Protocol is to ensure that the data is collected, presented, and analysed in a consistent manner throughout the research project. Although a single researcher is collecting the data, it is important to make sure each workshop is conducted in a similar fashion, hence the development of this document.

The data collection and reporting process comprise of four phases as illustrated in Figure 1 below. Each phase is explained in greater detail in the main body of the report.



Unit of analysis

Before undertaking this research project, it is necessary to be fully aware of the unit of analysis under investigation during each stage of the research. Empirical work will be carried out in a workshop environment with participants from the case study firms. This research is specifically interested in key activities that encompass inbound open innovation. Therefore, workshops will reflect this focus as the unit of analysis. Overall, these key activities comprise of (1) how the project team senses opportunities in the external environment, (2) how these identified opportunities are seized upon, and (3) how external knowledge/resources are integrated within internal operations.

As a guide, this research is interested in:

- Large firms operating in the energy industry
- Conducting interviews with engineers and managers who have a focus on R&D, technology, and business improvement
- Finding out the level of maturity with regards to key inbound activities
- Finding out the processes involved and performed for each inbound activity

As a guide, the following table can be used as selection criteria for choosing companies to study.

Industry	Employees	Technology orientated	Evidence of openness	Location to researcher	Firm office
Oil & Gas Renewables Electrical Nuclear	> 1,000	Yes	Yes	Local/some travel	Innovation/ Technology Centre

Phase 1. Set up

Before the research can begin, it is necessary to approach each company and seek permission to conduct the research investigation. A description about the nature of the research and potential data collection methods are worthwhile to highlight at the outset. If permission is granted, certain administrative and organisational issues will need to be addressed to ensure a smooth running of the process. Moreover, before conducting the case study workshops, it is important to gather some general background information relating to each firm. This will help to familiarise oneself about the company's operations.

Desk research

Gathering background information about each case study firm prior to visiting them is advisable. Things of importance may include:

- What the company does
- How the company is performing

- How they compare to their competition

The sources of information to use include:

- Company website
- Company annual reports
- Company reports/newspapers
- Online press releases
- Industry specialists

Meeting with company contact

Access to the case study firms will likely be through a key contact with whom the conditions of the research will be agreed. Furthermore, it is advisable to meet with this individual to gather more background information on the company, and uncover potential interviewees. The initial meeting should cover the following points:

Administration

- Timescales
- Access to:
    - People (who and how to contact)
    - Facilities (where interviews will be carried out)
    - Documentation (check that some access to documents will be allowed)

Confidentiality

Throughout the research, confidentiality of interviewees will be maintained at all times. For peace of mind, this fact should be stressed at the outset before the research begins. If required to sign formal confidentiality agreements, this should be respected. To make sure that the confidentiality agreement forms do not hinder total publication of findings, it is recommended that the researcher seek advice from their supervisor(s) before signing any documentation. On part of the researcher, he/she agrees that:

- Individual names and other personal information that may identify the interviewee will not be used
- Only job roles will be used to describe individuals
- Workshops will be recorded to allow for accurate quotations to be made
- Data will be allowed to be used in the process of completing a PhD thesis and subsequent publications

Overview of the firm

The aim here is to gain an appreciation for the company as a whole in the following areas:

- Brief history of the firm e.g. when it started, change of ownership, significant changes
- Size and ownership e.g. number of employees, turnover

- Products and services offered – past, present, and future
- Markets – customers, competitors, and suppliers
- Current state of the business, including a brief history of business performance
- Future direction and growth plans

Documentation

Access to company documentation will vary from firm to firm. Try to gather as many documents/reports etc as possible as this will help when asking questions in key areas. Typical documents include:

- Management information e.g. key performance indicators, board/management papers, financial and other performance papers
- Organisational structures
- Company internal communication (Intranet, newsletter, newspaper)
- Product development process documentation
- Innovation documentation

Phase 2. Formulate workshop strategy

Pilot workshop

The researcher should conduct a pilot workshop with colleagues from the university. The pilot workshop will provide the researcher with the opportunity to test the soundness of the questions before the real workshops. The pilot workshop will also allow the researcher to gauge how long the workshops will take in practice, and enables them to receive feedback on the overall format. For the pilot workshop, the researcher should deliver a Power Point presentation to the attendees, outlining the purpose of the workshop, the agenda, and the benefits for them taking part. The pilot workshop should follow the same procedure as the real workshop (detailed below).

Workshops

Once the researcher is satisfied that all areas of planning for the workshop is complete, the researcher may begin to start asking teams for workshop participation and to organise dates to conduct the workshops with the case study companies. Ideally, each workshop should involve approximately 5 participants of a specific project team. The researcher should find out who the team leader is for each group within the R&D/ Technology Centre or service office, and approach them asking if their team would be willing to participate in the workshop. Whilst doing this, provide the team leader with a paper document that outlines what the workshop will involve so that they can make a more informed decision. Ask the team leader for a copy of their email address so that you can forward any additional documentation on.

Points to bear in mind:

- It would be useful to provide the team leader with a range of dates and times when the workshops could be conducted
- Agree on date and time through e-mail (e-mail trail)
- Contact team leader to remind them of workshop 1 week before
    - Give team leader a document with information about yourself without too much detail, and tell them that there is no need for the workshop participants to prepare anything in advance
- Allocate 2 ½ hours per workshop in case some run for longer than anticipated

Phase 3. Conducting the workshops

The following points provide a sequential listing order for activities to be performed during the workshop:

Stage 1 of the workshop (individual exercise)

1. Before the workshop begins:
    a. Make sure to have all necessary material (Power Point slides, laptop computer, charger cables, portable projector, flipchart paper, marker pens, post-it notes, blu tack, video/audio recorder and participant folders with all documents inside)

    b. Place a folder with all necessary documents for the workshop on each table for every participant (participant information sheet, all three dynamic capability maturity level information sheets, example process map, Power Point slides, and workshop information sheet)

    c. Set up laptop, projector, and load Power Point slides

2. Once participants arrive:
    a. Get them to write their name on the provided piece of card so that the facilitator can see who everyone is

    b. Ask participants to open the folder in front of them and fill out their details on the participant information sheet provided

    c. Start Power Point presentation - introduce yourself and the purpose of the workshop, explaining that the aim is to measure the level of maturity for certain innovation activities and find out what processes the project team employs

    d. When finished, ask if there are any questions

    e. Ask participants to open their folder and get out the ‘sensing opportunities’ table

f. Talk the participants through each level of basic, intermediate, and advanced for 'sensing opportunities'. Do not read the full table – make sure to have short, snappy sentences to illustrate the essence of the table, then ask them to individually rate what level they think their team operates at (1, 2, 3, 4, 5, 6, 7, 8, 9).

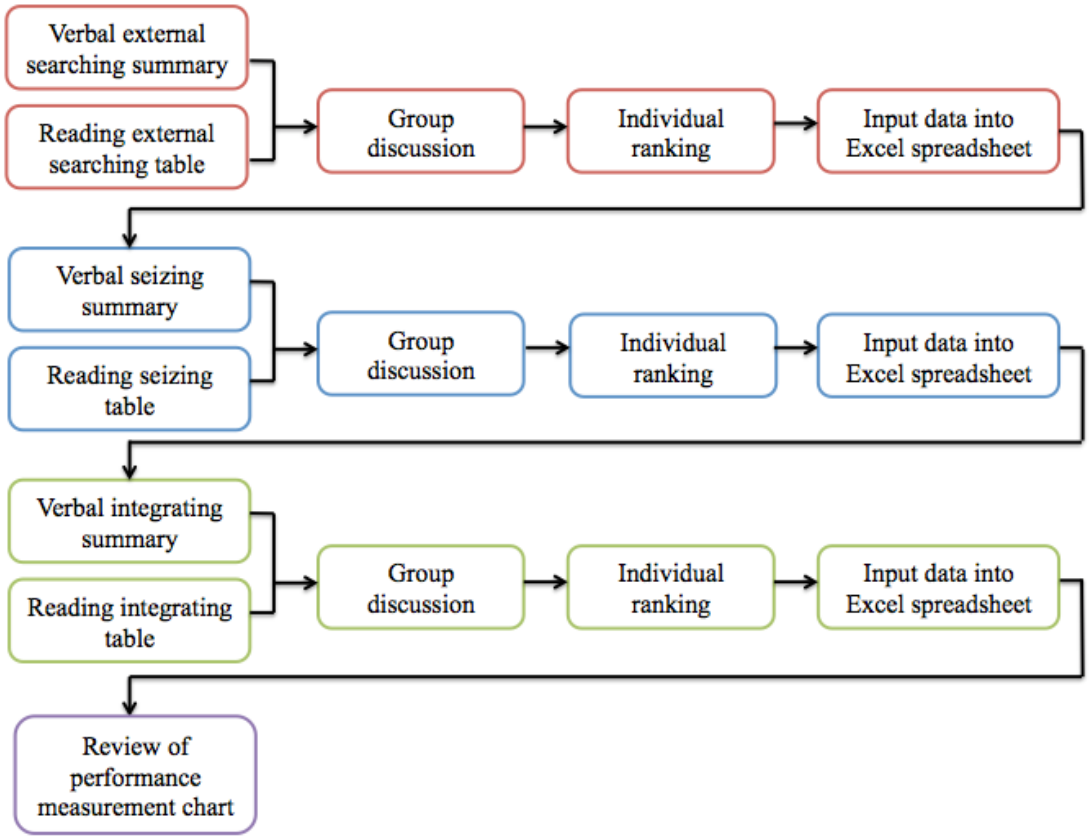
g. Ask participants to write their answer to 'sensing opportunities' in table 2 on the participant information sheet

h. Systematically go around each participant, asking them to feedback their assigned rating

i. Collate these ratings and populate the data into the Excel document, which will calculate the average maturity level for 'sensing opportunities'

j. Complete this process again for 'seizing opportunities' and 'transformational activities'

k. Once this is done, the Excel file will create an innovation footprint for the team based on the scoring system they have provided – show this to the group



Stage 2 of the workshop (group exercise)

1. Note the level of maturity for 'sense opportunities' and ask participants to explain reasons for performance levels of each innovation activity. Is it the same rating for everything?

2. Ask the group to map the process of the 'sense' activities performed using the flipchart paper and pens provided

3. Suggest to participants that it may be easier to use the post-it notes to write the process performed, and then assemble them in the correct order onto the flip chart. This will allow them to draw a connecting line from one process to another

4. Provide participants with an example process map, explaining that absolute accuracy in terms of drawing skill is not important, but more that the processes performed are as accurate as they can be

5. Ask the group to talk you through the process map, describing and explaining the process

6. This process should be adopted for both seizing and transformational activities

7. Finally, ask the group to conclude their strengths and weaknesses for each innovation activity (sensing, seizing, and transforming)

8. Once this is done, signal the end of the workshop, mentioning that a case study report will be provided to the team. Do not forget to thank everyone for their participation in the workshop

9. Remember to take photographs of each process map (post-its can fall off). Also, reinforce post-its with Sellotape.

******IMPORTANT******

Do not fail to get the participants to list the processes involved for the activities. If the process is very systematic, get them to document each step. If it helps them, get them to map the process out on flipchart paper

******IMPORTANT******

Workshop frequency

The aim is to conduct 3 workshops per company. However, if the researcher is only able to conduct 1 or 2 workshops per company, this will suffice, and additional companies will need to be sought to participate.

Event of non-workshop
If the situation arises whereby the company is unable to commit resources to satisfy a workshop, but is willing to offer an interview instead, the researcher should accept the invitation. The researcher should ask questions based on the developed question sheet.

Phase 4. Analysing data

Analysing workshop data
Although the data will be populated into tables and discussed during the workshops, additional time will be required to further analyse the results and write up a case report for each company. The case report for the company will be different to the case analysis for the PhD thesis. The analysis for the PhD thesis will require the researcher to assess what capabilities and processes are required for firms to benefit from inbound open innovation and to highlight the factors impacting on the design of an internal open innovation system.

Case study report write up

Once each case study has been analysed, the researcher will produce a detailed case study report, which will be structured as follows:

- **Introduction** – a brief history of the case study, including who participated in the workshop and the approximate start and finish times of the session

- **Business Context** – a brief introduction to the case study company that is being studied. This section should include:
    - An overview of the sector the company operates in
    - Main products and markets served
    - Brief history of the company
    - Company structure

- **Innovation environment** – first, provide a summary of what the innovation environment means (as per the literature), then describe how the company's position in relation to this theme.

- **Business processes** – as sensing

- **Individual roles** – as sensing

- **Performance measurement** – as sensing

- **Researcher conclusions** – include a short conclusion based on the data collected from the workshops. Note any strengths and weaknesses addressed by workshop participants.

Appendix 4: Interview questions

DEPARTMENT OF MANAGEMENT SCIENCE

University of Strathclyde Business School

University of Strathclyde
Department of Management Science

PARTICIPANT INTERVIEW INFORMATION SHEET

Interview data	
Employee name:	
Job title:	
Company name:	
Team/department name:	
Date:	
Time:	
Interview location:	

Introduction

Throughout my PhD research I have identified three key areas related to innovation, which I would like to investigate further during this interview. This includes:

- The external search process
- The seizing process
- The integration process

External searching

1. Innovation environment
    a. Can you describe what the innovation environment is like and what open innovation means within the company
    b. How is open innovation communicated across the company?

2. Business processes/routines
    a. How does the situation arise whereby the firm decides they want to bring in external technology?
    b. Can you describe the search process in detail for me? Is there a defined and documented process?
    c. In what type of places would the firm look? Industry?
    d. How is this search organised? Is it through a particular strategy?

3. Individual roles
    a. How does the company organise personnel for external searching? Are there specific job roles/open innovation teams?

4. Performance measurement
    a. Does the company perform any kind of analyses/performance measurement of the external searching activity?

Seizing external opportunities

1. Innovation environment
    a. Describe the ability of individuals to identify promising external technologies
    b. What is the attitude towards external technologies being brought in to the company?

2. Business processes/routines
    a. How does the firm make contact with the external who holds this new technology/knowledge?

3. Individual roles
    a. Who makes contact with the external?

4. Performance measurement
    a. Does the company perform any kind of analyses/performance measurement on the seizing process?

Integrating external opportunities

1. Innovation environment
    a. Describe the environment in the firm when an external technology is brought into the company/when the firm is working on a collaboration with an external (trust issues/knowledge sharing/commitment/IP issues)

2. Business processes/routines
    a. How does the firm integrate external knowledge/technology within the company?

3. Individual roles
    a. Describe the human role during the integration phase. How do people in the firm contribute to this process?

4. Performance measurement
    a. Does the company perform any kind of analyses/performance measurement on the integration process?

Appendix 5: Conference paper 1

A framework for measuring open innovation maturity levels

MacKinven S, MacBryde J, and Wagner B. 2013

20th EurOMA Conference: Operations Management at the Heart of the Recovery, 7-12 June, Dublin, Ireland

Appendix 6: Conference paper 2

Open Innovation Management through Strategic Implementation

MacKinven S, MacBryde J, and Wagner B. 2014

R&D Management Conference, 3-6 June, Stuttgart, Germany

Appendix 7: Conference paper 3

Sensing opportunities: is there a need for a managed search process in open innovation?

MacKinven S, MacBryde J, and Wagner B. 2014

21st EurOMA Conference, 20-25 June, Palermo, Italy

Appendix 8: Conference paper 4

Modelling the Strategic Adoption of Open Innovation for Improved Decision-Making

MacKinven S. 2015

27th European Conference on Operational Research, 12-15 July, Glasgow, Scotland