Revealing Knowledge in Open Innovation

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ABSTRACT

This thesis provides insights into *revealing* of knowledge in open innovation (OI). Revealing is beneficial to attract non-pecuniary benefits that are at times, preferred by firms in place of immediate revenue. However, the implementation of it is found to be challenging. Literature on revealing and related fields indicate firms may implement revealing in different ways but do not offer explanations nor present a conceptualisation to understand the variation. Studies explaining implementation to an extent, are limited to open source software and cannot be replicated in other contexts. Therefore, this study aims to address the question of 'why and how do firms implement revealing?' by focusing on understanding and explaining revealing implementation in multiple firm contexts.

A review of revealing, and its overlapping concepts derived four revealing behaviours that characterise variation in implementation based on the 'access to the revealed knowledge' and the 'amount of knowledge revealed'. Furthermore, the review identified firm-level factors that influence revealing, namely drivers to reveal, and firm capabilities, and key revealing mechanisms. Integrating the four behaviours (extreme, content-controlled, access-controlled and restrictive revealing), revealing mechanisms, and the firm-level factors, a conceptual framework was developed to guide the empirical study. The empirical process followed a qualitative multiple case study approach to investigate the implementation of revealing across five case firms in New Zealand.

Findings indicate that revealing implementation is largely determined by the drivers to reveal. Drivers present the strategic goals for revealing and guide the choice of revealing behaviour/s. Codification and modularising are essential capabilities for revealing regardless of the type of revealing behaviour. Strategic actions, associated with the revealing behaviour, are used to manage the implementation to minimise risks and/or enhance outcomes.

The thesis contributes to the revealing literature by systemising the overlapping concepts and different forms of revealing to present the four behaviours. Second, the empirical study refines the current conceptualisation of revealing by integrating the four behaviours with firm-level factors – drivers to reveal, capabilities and strategic actions to explain the implementation in firms. Finally, an overarching conceptualisation is presented for revealing in OI that can be replicated across multiple firm-contexts for future research.

DEDICATION

I wholeheartedly dedicate this thesis to my parents Peter and Malanie, for teaching me the value of education, but most importantly, the value of kindness, humility, and compassion.

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CHAPTER 1 INTRODUCTION

"To this end, and in support of the public health and medical response of governmental agencies around the world, Medtronic has publicly posted design specifications for the Puritan BennettTM 560 (PB560) ventilator to allow innovators, inventors, start-ups, and academic institutions to leverage their own expertise and resources to evaluate options for rapid ventilator manufacturing." – Medtronics, 2020

*"The 'open' project will utilise Cobra's [*Cobra Biologics*] 50L DNA suite in Sweden to produce the plasmid DNA. The plasmid production will support the vaccine development process in accordance with GMP and with a new kind of 'open'-ness that will help to speed the fight against COVID-19 by making relevant data and research results available to the wider scientific community." – HealthEuropa, 2020*

The purposive outflow of internal knowledge is an integral part of the open innovation (OI) paradigm (Chesbrough, 2003a; Dahlander & Gann, 2010; Gassmann & Enkel, 2004). Innovative firms, at times, share all or parts of internally created knowledge with external parties without immediate revenue – a phenomenon termed *revealing* (Dahlander & Gann, 2010). Revealing refers to voluntary knowledge outflows from the firm that do not generate immediate revenue (Dahlander & Gann, 2010).

Open knowledge flows in innovation was never more imperative than now, during the COVID-19 outbreak (Chesbrough, 2020). Key developments in response to the pandemic require quick and efficient innovative solutions to various problems in product development, supply chain and logistics. This challenged the status quo of innovation in industries such as pharmaceutical and medical engineering, by having to mobilise globally dispersed expertise and infrastructures to develop vaccinations, effective testing methods, personal protective equipment (PPE) and medical equipment (e.g. ventilators). As a result, firms across the globe are freely sharing knowledge to address these challenges. For example, pharmaceutical firms are collaboratively developing vaccines by sharing expertise, costs of development and infrastructure[1]. Cobra biologics is taking part in two consortia – OPENCORONA[2] with Karolinska Institute, and ChAdOx1[3] with Oxford University, Vaccines Manufacturing and Innovation Centre, Advent Srl, Pall Life sciences and Halix BV – to rapidly develop and trial COVID-19 vaccines. Cobra biologics which is a contract developer and manufacturer (CDMO) for biologics and

[1] https://fortune.com/2020/03/26/coronavirus-vaccine-drug-development-open-science-covid-19-treatment/
[2] https://www.cobrabio.com/News/March-2020/Cobra-Karolinska-Institutet-COVID-19-Vaccine
[3] https://www.cobrabio.com/News/March-2020/Cobra-Jenner-Institute-consortium-COVID-19-vaccine

pharmaceuticals are sharing their expertise in DNA, viral vectors and drug development with research institutes and other CDMOs to accelerate the development and clinical trials of a vaccine for the coronavirus. Medtronics, which is the developer and owner of Puritan Bennett 560 potable ventilator, is openly and freely sharing its ventilator designs to overcome the shortage in ventilators[4]. The aim is to accelerate and increase the production of ventilators worldwide. At the time of this publication, the designs have been accessed by more than 90,000 entities. Additionally, independent research teams such as MIT E-Vent have developed a low-cost ventilator and are sharing the design guides as living documents. These documents are consistently updated with new developments and testing results[5]. In another example, tech giants such as Amazon, Facebook, IBM, and HP are also pledging their patents for free use by anyone to fight the pandemic[6]. Such efforts in revealing by various entities across the globe are directly providing the necessary intellectual capital and indirectly the human, physical and financial capital to speed up the process of development, clinical trials, prototyping and testing of various solutions to fight the COVID-19 pandemic.

Application and benefits of revealing, however, is not specific to crisis-situations. Firms have revealed internally created knowledge to external parties, including competitors (Chesbrough, 2003b; Dahlander & Gann, 2010) even before the current pandemic crisis (Chesbrough, 2020). Knowledge of the firm is a key source of competitive advantage (J. Barney, 1991; Grant, 1997; Nonaka, 1994) depending on to what extent it is proprietary (Polidoro Jr. & Theeke, 2009; Polidoro Jr. & Toh, 2011) and could generate a tangible income (De Fraja, 1993; Muller & Pénin, 2006). Firms that reveal, go against this notion and disclose internal knowledge for non-monetary incentives. In the absence of a financial incentive, firms reveal for various benefits such as reputational gain, collective learning and development, valuable knowledge inflow and to benefit from advancements in the industry as a whole (Alexy et al., 2013; de Jong & Flowers, 2018; Harhoff et al., 2003; Henkel et al., 2014; von Hippel, 2005a). With the increasing openness in innovation, revealing can be used as a strategy to create value in the absence of a strong appropriability regime (Dahlander & Gann, 2010). With porous boundaries, firms find it difficult to completely protect internal knowledge due to involuntary spillovers (Frishammar

[4] https://www.nsmedicaldevices.com/news/medtronic-pb-560-ventilator-design/
[5] http://news.mit.edu/2020/ventilator-covid-deployment-open-source-low-cost-0326
[6] https://creativecommons.org/2020/04/20/tech-giants-join-the-cc-supported-open-covid-pledge/

et al., 2015). In such occasions, being preemptively open and revealing the knowledge can derive more benefits to the firm than trying to sell (Sarkar, 2017a).

However, firms implement revealing in different ways. In recent real-world examples, two innovators – Tesla and Microsoft – revealed their internally developed knowledge in two different ways. Tesla follows an unrestrictive approach to revealing, while Microsoft is restrictive.

Tesla is making all patents open source without any restrictions to access[7]. Tesla's patent pledge[8] gave them the ability to access patents of firms that use Tesla patents without being infringed (Hill, 2016; Lambert, 2015). This gives Tesla the benefit of sourcing (opposite of revealing in OI – free inflow) knowledge for Tesla's innovations in the electric-powered equipment eco-system, in addition to other benefits such as fewer patent litigations, reputation and accelerated developments in the electric automobile sector.

Microsoft, on the other hand, is making selected patents available only to a single community of users – the open invention network (OIN)[9]. Anyone outside the OIN will still be bound by the usage restrictions of the patents. Microsoft joined the OIN to support the protection it offers the open source software (OSS) community against patent aggression (Schauweker, 2018). It has integrated OSS products into the Microsoft platforms even before joining OIN. By joining the OIN, Microsoft gained a reputation as a supporter of OSS. In addition to reputation, Microsoft now can gain the advantage of a large network of corporates, small firms and individual developers of Linux based applications for free after joining OIN.

The current theoretical understanding of revealing is limited in explaining why and how such variations exist in revealing implementation. Reported studies that explore free knowledge outflows lack consensus in terms of defining the boundaries of such flows, are conceptual or are predominantly focused on specific mechanisms such as OSS. For example, Alexy et al. (2013) present theoretical arguments for the implementation of 'selective revealing' which refers to a restrictive flow of knowledge from firms. Free-revealing studies (Harhoff et al., 2003; von Hippel, 2005a) refer to a knowledge flow that creates public good, i.e. unrestrictive access. Others provide insights into implementing revealing through OSS (Henkel et al., 2014;

[7] https://www.tesla.com/blog/all-our-patent-are-belong-you
[8] https://www.tesla.com/about/legal#patent-pledge
[9] https://azure.microsoft.com/en-us/blog/microsoft-joins-open-invention-network-to-help-protect-linux-and-open-source/

von Hippel & von Krogh, 2006). Then there is another stream of literature on 'open and closed disclosure' (Muller & Pénin, 2006; Pénin, 2007). These scholarly work discuss forms of knowledge outflows that represents revealing but are inconsistent in defining the boundaries of such flows. Furthermore, none of the studies provides empirically derived insights for their implementation. As further outlined in section 1.1, findings of existing scholarly work significantly contribute to gain insights on aspects of revealing such as motivations, mechanisms, and risks; but fail to generate a unified stream of scholarly work that can provide empirically-driven insights on revealing implementation (c.f. Dahlander & Gann, 2010).

This study aims to address this lag in theory by exploring revealing implementation across multiple firm contexts. The focus is on developing a unified framework for revealing within OI, that elucidates the variations in implementation.

1.1 The current conversation on revealing – knowns and unknowns

So far, the prior empirical research in revealing is predominantly focused on understanding the motivations to reveal (Harhoff et al., 2003; Henkel, 2009; Henkel et al., 2014; Schweisfurth et al., 2011; von Hippel, 2005a). Fewer studies are directed at understanding the mechanisms, risks and different types of revealing.

The scholarly work on *motivation to reveal* explores why firms engage in revealing at all (Alexy et al., 2013; Harhoff et al., 2003; Henkel, Schöberl, et al., 2013; von Hippel, 2005a). As a knowledge outflow that does not generate immediate revenues, firms reveal in the expectation of other intangible benefits. Examples of such benefits include but are not limited to reputational gain, image building, industry advancement, collective development and learning, access to markets, and access to expertise and resources.

Mechanisms and business models are the operational aspects of revealing. Often, they are connected in the revealing process (Alexy & Reitzig, 2013; Lhuillery, 2006; Pénin, 2007; Schweisfurth et al., 2011; von Hippel & von Krogh, 2003, 2006). One example is the open source model where the process knowledge is revealed and the products are appropriated; the associated business model is termed the 'private-collective' model (von Hippel & von Krogh, 2006). Other examples are collaborative development, which includes user innovation and crowdsourcing, and publications and patents.

Conversation on *risks of revealing* is scarce but important. The existing scholarly work on this topic is limited to understanding the potential risks of involuntary leakage of core knowledge when opening firm boundaries for knowledge outflows (Frishammar et al. 2015; Ritala et al.

2015, 2018). The challenge for firms of striking the right balance in the amount of 'openness' when revealing is a common theme in the research. This concern has been echoed in multiple scholarly studies over the years (Bianchi et al., 2014; Brunswicker & Chesbrough, 2018; Chesbrough & Brunswicker, 2014; Chesbrough & Crowther, 2006; Chiaroni et al., 2011).

Finally, *different types of revealing* are indicated in the scholarly work in the form of *selective-revealing* and *free-revealing* (Alexy et al., 2013; Harhoff et al., 2003; Henkel, 2006; Henkel et al., 2014; Lakhani & Wolf, 2003; von Hippel, 2005a; von Hippel & von Krogh, 2006). Free-revealing refers to knowledge outflows where the firm relinquishes rights to all knowledge, thereby making it a public good (Harhoff et al., 2003). Selective- revealing, on the other hand, involves firms applying *selectivity* to rationally weigh the trade-off between the benefits of revealing and appropriation in deciding which knowledge components to reveal.

Despite the attention received by the phenomenon, the revealing literature still lacks insights to explain the rationales behind the varied approaches and processes of implementation outlined at the beginning of this chapter. Revealing still needs scholarly work to problematise it in ways that add the necessary clarity required for conceptualisation. The three key issues of concern for this study are:

(a) the lack of clarity on the overlaps and boundaries with concepts similar to revealing;
(b) the lack of insights into the real-world implementation of the concept in multiple contexts; and
(c) the predominance of the Open source software (OSS) context in theory building thus far.

Addressing these issues in an empirical study on revealing is important for theory building and further development of the concept. The issues are discussed further below.

First, revealing has widespread roots in other fields, which inevitably presents multiple conceptual overlaps. A review of the literature shows that scholars in related fields such as R&D management and R&D economics use several terms to refer to phenomena similar to revealing – knowledge disclosure (Boudreau & Lakhani, 2015; Lhuillery, 2006; Pénin, 2007), voluntary spillovers (Bloch, 2013; Harhoff et al., 2003; Montoro-Sánchez et al., 2011), and external knowledge sharing (Ritala et al., 2015, 2018). These concepts underlie different variations of revealing, such as free- and selective- revealing (Harhoff et al., 2003; Henkel, 2006). Such variation in forms and definitions adds richness to the concept. But the lack of clarity in the definitions and their boundaries is problematic for theory development.

Frameworks similar to Dahlander and Gann's (2010) OI framework are useful for simplifying complex phenomenon into smaller constructs that can be applied in an empirical setting. Revealing also requires such frameworks to integrate the multiple perspectives, different definitions and nuances of the concept. Exploring the boundaries, activities, and application of the concept in different organisational settings provides a good starting point for empirical research (Huizingh, 2011).

Secondly, the effective implementation of revealing is important to ensure beneficial outcomes while protecting the firm from the risk of involuntary leakage of core knowledge (Frishammar et al., 2015; Ritala et al., 2018). Revealing is beneficial when firms share valuable knowledge with potential users (Frishammar et al., 2015). However, striking a balance between revealing 'too-little' or 'too-much' is a challenging task (Frishammar et al., 2015; Ritala et al., 2018), and depends on a multiplicity of factors such as the nature of the knowledge, intentions for revealing, and the potential benefits (Alexy et al., 2013; Harhoff et al., 2003; Henkel et al., 2014). It is therefore logical to assume that not every firm can or will implement *revealing* in the same manner (Alexy et al., 2013; Boudreau & Lakhani, 2015; Harhoff et al., 2003; Henkel et al., 2014). In order to understand the implementation of revealing, an area that is lagging compared to other OI concepts, more studies are needed that link revealing with related firm-level concepts such as the strategic goals of the firm, firm capabilities, nature of innovation and knowledge, and expectations for outcomes (Bogers et al., 2018; Stanko et al., 2017). The extant literature on revealing does not present evidence-based explanations for the variation, nor does it explain what factors in a firm influence such variation.

Finally, key studies contributing to a deeper understanding of the implementation of revealing are predominantly based on OSS contexts (Henkel, 2009; Henkel et al., 2014; von Hippel & von Krogh, 2003). Insights from OSS are important for adding nuances to the concept but are not generalisable across multiple firm contexts. OSS is not only a mechanism for revealing but a business model itself (Stanko et al., 2017; von Hippel & von Krogh, 2006). Therefore, the method possesses unique characteristics in terms of revealing in the innovation process. For example, source code and machine-readable software are two independent modules of the same innovation, and the source code module can easily be made a public good without affecting the commercial value of the software (Henkel & Baldwin, 2009; von Hippel & von Krogh, 2006). The motivations, business model and the related revealing mechanisms used in the OSS sector are unique and only applicable in industries that can adopt open source principles (see Schweisfurth et al., 2011 for some examples).

Such lags in the literature on revealing are even more problematic considering its relationship with allied concepts in OI. Non-pecuniary knowledge inflow, one counterpart of revealing in OI (Dahlander & Gann, 2010), has been studied extensively to understand its implementation, links with other firm-level concepts, variations in inbound flows, and even effectiveness for internal innovation (Fey & Birkinshaw, 2005; Grimpe & Kaiser, 2010; Laursen & Salter, 2006; Parida et al., 2012; Sisodiya et al., 2013; von Hippel, 1986). Across several fields, such studies have developed understanding of the foundations of allied concepts, clarifying their boundaries and implementation in firms. For example, sourcing has been empirically studied to understand variations in its implementation, rationales for doing so, and its effectiveness in firm innovation (Laursen & Salter, 2006; Sisodiya et al., 2013). Revealing, however, has not received such widespread attention. As is in the idiom 'two sides of the same coin', the inbound and outbound forms are closely related in OI (Huizingh, 2011; Stanko et al., 2017; Tranekjer & Knudsen, 2012). This is evidenced in a number of scholarly works. Chesbrough & Crowther (2006) have shown that within an industry, every inbound effort has a reciprocal outbound effort. This is applicable where some form of outbound flow from a firm is required to receive an inbound knowledge flow (Bogers, 2011; de Jong & Flowers, 2018; Gassmann & Enkel, 2004). Thus, the quality and existence of the inflow depends on the quality and existence of the outflow. Considering the importance of the relationship between revealing and sourcing, it is problematic that the concepts are not equally understood.

Therefore, the aim of this study is to elucidate how firms actively involved in innovations implement revealing to derive intended benefits while at the same time minimising the risks.

1.2 The research aims and question

To fill in the gaps in the literature outlined above, this study will address the following research question:

Why, and how do firms implement revealing?

The main objective is to shed light on the variation in revealing implementation by developing a framework that integrates related firm-level factors and their interplay in revealing activities in multiple firm contexts. In doing so, the study will add insights currently missing from the revealing literature, to explain how firms can overcome the challenges associated with implementing revealing in a strategic manner.

Understanding how firms implement revealing is important to developing theory around strategising a risky but useful phenomenon. The study assumes that despite the challenges,

firms still reveal. Exploring the implementation of revealing is therefore useful to developing frameworks to guide future empirical work. Such frameworks may further facilitate managers to strategically implement revealing in a beneficial manner, without compromising the core value of the firm.

1.2.1 Significance of the research

This study identifies various revealing behaviours and empirically explores corresponding firm-level factors that influence revealing in multiple firm contexts. First, the study identifies revealing behaviours that characterise variation in its implementation by firms through a thorough review of the relevant literature. This step will help eliminate the ambiguities that currently exist around the concept, clarify the boundaries, and through consistent conceptualisation, contribute to a unified framework for revealing to provide the basis for future empirical work.

Second, the study identifies firm-level factors that influence revealing – e.g., firm capabilities relevant to managing knowledge resources. In the empirical phase of the study, these factors are explored to identify their relevance to revealing, and their interplay in revealing behaviours. Identifying these relationships provide the insights to explain why and how firms strategise the implementation of revealing.

Finally, the multiple firm-contexts expand the applicability of the findings beyond OSS. Firms find implementing revealing challenging (Brunswicker & Chesbrough, 2018; Chesbrough & Brunswicker, 2014), and hence are wary of engaging in revealing (e.g. Bianchi et al., 2014; Chesbrough & Crowther, 2006; Chiaroni et al., 2011). As emphasised in the preceding section, the prevalence of the OSS context in empirical studies adds richness to the concept but is not useful in terms of providing generalisable insights to firms on how to strategically implement revealing.

In summary, this study explores revealing behaviours and corresponding firm-level factors across multiple firm-contexts to more clearly conceptualise revealing and its nuances, and thereby add insights on its application in real-world settings. Similar studies in OI has contributed the model to be implemented across a broad context varying from products and service firms to government organisations and public policy (Wikhamn, 2019). This thesis, therefore, aims to present a viable exploration into the implementation of revealing in order to encourage its applicability in firms.

1.3 Theoretical perspectives

This study integrates literature from several theoretical fields to develop the conceptual framework that guides the empirical study. The integration of theoretical perspectives is significant at two levels – (a) to clarify the boundaries of revealing by reviewing the overlapping concepts, and (b) to identify the mechanisms of revealing and their theoretical grounding for the purpose of identifying the firm-level factors.

First, the review addresses the multiple conceptual overlaps present in scholarly works variously grounded in Research & Development (R&D) management, R&D economics, and open innovation (OI) and innovation economics. Examples of overlapping concepts identified include:

a) Collective invention (Allen, 1983),
b) Technological and knowledge spillovers (Harhoff, 1996; Montoro-Sánchez et al., 2011),
c) Knowledge and technological disclosure (Boudreau & Lakhani, 2015; Lhuillery, 2006; Muller & Pénin, 2006; Pénin, 2007).

More specific variations of revealing are identified in the OI, user innovation and collaborative innovation literature (e.g. Alexy et al. 2013; Bogers 2011; Harhoff et al. 2003; Henkel 2006; Henkel et al. 2014; von Hippel and von Krogh 2006). These studies are instrumental in deriving the different applications of revealing – *revealing behaviours*, that characterise the variation in implementation between the case firms.

Next, the study integrates the findings from the following scholarly work to understand the theoretical grounding for revealing mechanisms:

a) Open science (Franzoni & Sauermann, 2014; Hicks, 1995; Simeth & Lhuillery, 2015; Simeth & Raffo, 2013),
b) Open source innovation (both software and non-software applications) (Henkel, 2009; Lakhani & Wolf, 2003; Raasch et al., 2009; von Hippel & von Krogh, 2003; West, 2003),
c) Collaborative innovation (Baldwin & von Hippel, 2011; Bogers, 2011; Montoro-Sánchez et al., 2011), and
d) Patent studies (Bhattacharya & Guriev, 2006; De Fraja, 1993; Jaffe, 1986).

Additionally, this study integrates theoretical insights from dynamic capabilities (Cheng et al., 2016; Eisenhardt & Martin, 2000; Kogut & Zander, 1992), and broadly from the resource based view (J. Barney, 1991; J. B. Barney, 2001) to identify revealing capabilities.

Finally, these perspectives are combined to develop the conceptual framework that illustrates the implementation of revealing in firms. The framework constructs discussed in Chapter 2 are drivers to reveal, revealing capabilities, revealing behaviours and revealing mechanisms.

1.4 Overview of research design

As an open-ended exploration is required to conceptualise revealing, this study uses a qualitative approach to the research design. This approach is suitable because the revealing literature lacks clarity around the boundaries of the concept, and it is currently disconnected from the relevant concepts in OI and innovation. There is not enough prior work on revealing specifically focused on its implementation to clarify the variables and develop metrics to accurately measure it in practice via quantitative means.

Furthermore, the research question and objectives of the study call for clarification of the existing conceptualisation as well as allowing space for the identification of new variables and relationships (Lichtenthaler, 2011; von Krogh, 2011). A major contribution of the study is to ease the way for future work by providing stronger conceptualisation of the construct to ensure consistency in theory development (Corley & Gioia, 2011). Therefore, according to the premise of 'asking the right question and picking the most powerful method to address it' (Bouchard, 1976), and finding the right fit between the research question, prior work, and the developed conceptual framework (Edmondson & McManus, 2007), this study employs a qualitative methodology, the multiple case study method (Yin, 2018), to address the research question. The use of case studies will help to explore revealing in real-world settings to gain nuanced insights and develop rich illustrations (Eisenhardt, 1989; Yin, 2018), guided by the conceptual framework. Rich case descriptions are developed from data collected through interviews, documents and field notes across five case firms to illustrate the case studies and aid in the cross-case analysis (Miles & Huberman, 1994; Yin, 2018). The case firms are New Zealand based entities actively involved in R&D activities that have commercial intentions for their innovations and have introduced one or more innovations over the past five years, from the time of data collection.

1.4.1 Definitions of key terms

The following definitions of key terms are specified to ensure a common perspective is applied across the entire study (Maxwell, 2012).

Openness of OI: The initial work on OI defines users and contributors of knowledge flows that create a 'public good' as the purest form of OI (Chesbrough & Appleyard, 2007), but not the only form of openness (Dahlander & Gann, 2010). For the purposes of this study, OI is defined as the process of being open (Gassmann & Enkel, 2004), where 'open' means having a permeable firm boundary. Knowledge can flow in and out at any point in the innovation process, intentionally and purposively. Revealing is such a knowledge outflow, but one that does not create immediate pecuniary revenue for the firm. Knowledge that is revealed may not be a public good. However, due to the broadness of this definition of 'openness', open source innovations and open science practices (which fall into both categories of openness) that create public good are considered part of OI.

Innovation and the innovative firm: This study adapts the definitions put forward by the OECD Oslo manual. Innovation is "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations" (2005, p. 46). In this definition 'new' is defined as entirely new or significantly improved 'to the firm'. The innovative firm "is one that has implemented an innovation" (OECD & Eurostat, 2005, p. 47).

1.5 Contributions

This thesis makes three main contributions to OI literature, specifically to revealing in the ways outlined below.

a) First, this study contributes to the revealing literature by introducing a framework that includes four revealing behaviours – *extreme, content-controlled, access-controlled and restrictive revealing*. In the process of deriving different behaviours, the nuances and similarities of several seemingly overlapping concepts are acknowledged. This provides clarity on the boundaries of revealing. The prevailing fragmentation in the concept is a significant lag in the revealing literature and OI, and potential barrier to empirical studies of the concept in practice. This study incorporates multiple scholarly works to develop an overarching conceptualisation of the concept. In doing so, it extends understanding of different revealing behaviours, intentions and mechanisms across all OI contexts, not just OSS. This further provides the much needed occasional

'house cleaning' required for concepts in the management discipline to guide empirical work that advances theory building (Corley & Gioia, 2011; von Krogh, 2011).

b) Second, the study develops a theoretically grounded conceptual framework that illustrates the key factors that influence revealing, and their effect on the revealing behaviours. For this, the study integrated theoretical insights, specifically from dynamic capabilities and more broadly from the resource-based view to develop the theoretical grounding for revealing capabilities. This addresses the current gap in revealing conversation on capabilities and links revealing, and OI with the mainstream theory which is a much-needed extension to the conversation on both revealing and OI (Bogers et al., 2018; Vanhaverbeke & Cloodt, 2014).

c) Finally, the study clarifies and builds on the prevailing conceptualisation of revealing that is predominantly OSS based. By exploring revealing across multiple firms, the study identifies the nuances of revealing that are not presented in the OSS context. The empirical study acknowledges multiple firm contexts, organisational factors and respective requirements for revealing. In doing so, it presents a conceptualisation that is applicable across multiple OI contexts. The conceptual model provides a starting point for future empirical studies, and support consistency and clarity in contributions to the field. Consequently, the study contributes to the OI conversation by clarifying an inherent construct of the OI model. Extending the understanding of non-pecuniary outbound innovation may potentially aid in maintaining the sustainability of the innovation model.

In addition to these theoretical contributions, the study further identifies best practices with managerial implications. The revealing behaviours and their links to the firm-level factors that influence them, provide insights for firms for deriving best practices for strategising revealing. Identifying best practices is useful in informing firms on how to overcome the challenges outlined in a number of prior research studies (e.g. Brunswicker & Chesbrough, 2018; Henkel et al., 2014). One of the key challenges is managing the risks of involuntary knowledge outflows (Ritala et al., 2018). The empirical part of the study provides examples of how the case firms have overcome the vulnerabilities of being open and steered the revealing process to achieve their intended goals effectively. These empirically derived insights may provide senior managers with the necessary guidance to implement and manage revealing activities appropriately, but effectively.

1.6 Structure of the thesis

This thesis comprises of six chapters. The current chapter has introduced the thesis problem and the objectives. It further provides an overview to the contributions and the research design.

Chapter 2 presents a review of the literature and theoretical grounding for knowledge flows across firm boundaries that are non-pecuniary in nature. The chapter endeavours to incorporate a rather fragmented conceptualisation of knowledge revealing by combining similar knowledge sharing phenomena discussed in theoretical domains such as R&D management, innovation economics, user innovation, collaborative innovation and open source innovation. The chapter contributes to theory by clarifying the definition and boundaries of revealing, and the possible revealing behaviours found in firms. It further presents a holistic view on the mechanisms of revealing across multiple theoretical domains which are not recognised in the OI domain. Revealing capabilities are identified via a review of literature grounded in dynamic capabilities and resource based view. The resulting conceptual framework guides the empirical analysis for this study. The concepts identified through the literature review relevant to addressing the research question and objectives are operationalised in this chapter.

Chapter 3 presents the research design. It explains the paradigmatic influence, rationale for the choice of qualitative methodology, the multiple case study method and the choice of data collection tools. The chapter also presents the analytical procedures used – coding cycles, triangulation, etc., illustrated by examples from the empirical study.

Chapter 4 is dedicated to the case descriptions, which are based on the within case findings. The same structure is followed across all five cases for clarity and comprehensibility. The case descriptions scope the relevant data to be analysed across cases.

Chapter 5 presents the analysis and findings in relation to the research question. The analysis is organised according to the conceptual framework.

Chapter 6 presents a discussion of findings in relation to the existing theory and research. An amended conceptualisation for revealing is put forward that explains the links between organisational factors and revealing behaviours. This is followed by discussion of the theoretical and managerial implications of the findings. The chapter then clarifies the limitations of the study and endeavours to present potential avenues for further research.

CHAPTER 2 LITERATURE REVIEW

This chapter reviews the concept of revealing in the OI literature. The review encompasses concepts and terminology similar to revealing from open innovation and other closely related theoretical fields such as R&D Management, R&D economics, Innovation management and User innovation. A keyword search on the Google scholar and web of science (Crossan & Apaydin, 2010; Dahlander & Gann, 2010; Podsakoff et al., 2005) was used to identify the relevant literature to review. The initial keywords included '*revealing*', 'free-*revealing*' and 'selective-*revealing*' and their derivatives. Using the backward and forward referencing methods (e.g. see Siedlok & Hibbert, 2014; Wang & Chugh, 2014; Webster & Watson, 2002), more literature was identified using keywords such as 'disclosure', 'Unmonetized outbound OI', 'non-pecuniary outbound OI' or derivatives thereof. These resultant papers were reviewed to identify specific elements of *revealing*, maintaining focus on the RQ at hand.

First, existing concepts that seem to overlap with revealing are investigated. The aim is to clarify the boundaries and definition of the concept – revealing. Second, it synthesises and systemises the allied concepts to introduce four key behaviours related to revealing in organisations. This is followed by an in-depth exploration and discussion of four key mechanisms of revealing. Finally, the chapter identifies and discusses firm-level factors relevant to revealing, namely drivers of revealing and firm capabilities. The findings of the review contribute to the formation of a conceptual framework to guide the empirical study. The framework is presented at the end of the chapter.

2.1 Clarifying Revealing – definition and boundaries

Revealing is a key concept of open innovation which aims to capture how and why firms share internal knowledge outside firm boundaries (Dahlander & Gann, 2010; Huizingh, 2011). Chesbrough and Appleyard (2007) refer to revealing as the 'purest form' of open innovation. In their study, Dahlander and Gann (2010) focused not only on the direction of knowledge flows but additionally on the logic of exchange to identify the main types of expectations that might motivate organisations to engage in OI (Figure 2-1). This framework furthers the concept of open innovation by presenting revealing as the non-pecuniary form of outbound innovation, i.e. the firm discloses internal resources to external parties without expecting an immediate financial return (Dahlander & Gann, 2010).

	Inbound innovation	Outbound innovation
Pecuniary	Acquiring	Selling
Non-pecuniary	Sourcing	Revealing

Figure 2-1: Four types of OI. Reproduced from Dahlander & Gann, 2010.

The argument put forward for revealing is that firms should make some knowledge resources of the firm available for resolving shared problems or to share innovative solutions (Alexy et al., 2013). As discussed later in the chapter, revealing is driven by specific strategic requirements in the firm. Therefore, revealing valuable knowledge is essential to achieve the expected goals. Revealed knowledge can include intellectual property, processual knowledge, or other knowledge resources that are outcomes of innovation activities in the firm (see examples in Alexy et al., 2013; Harhoff et al., 2003; Henkel et al., 2014; Lhuillery, 2006; Linåker, Munir, Wnuk, & Mols, 2018; Pénin, 2007; von Hippel, 1989). The revealed knowledge is not necessarily a public good, but rather either public or 'private' knowledge shared between selected partners – or a mix of both.

Therefore essentially, a knowledge flow must satisfy four fundamental criteria to qualify as revealing: (1) It originates from a firm; (2) It is intentional and purposive; (3) It penetrates the firm boundary; and (4) It does not generate immediate financial revenues to the firm.

The above definition has implications in terms of boundary setting for the concept as it includes any knowledge outflow from firms that satisfies the four criteria. Even though the knowledge need not be an output from the firm's R&D activities, it should still be innovative and of value (Alexy et al., 2013). Therefore, this definition necessitates knowledge outflows that are of value to potential users but excludes the involuntary leakage of innovative knowledge that may occur in collaborations or network environments. Further, this definition does not mean that users of the revealed knowledge will not incur any costs to be able to utilise it (Pénin, 2007; von Hippel & von Krogh, 2006). Users may still have to bear some cost, i.e. payment to a third party to access the knowledge in the form subscriptions to the journals themselves or databases that provide access to academic articles, for example. However, any such payments do not flow back to the revealing organisation as immediate revenue in exchange for the knowledge.

There are similar concepts in related fields that closely represent revealing. The following section review three concepts – collective invention, spillovers and knowledge disclosure – to understand similarities and differences in relation to revealing.

2.1.1 Overlapping concepts

Similar and seemingly overlapping concepts to revealing exist in open source innovation, knowledge sharing and R&D management. As detailed in Table 2-1, the review considers several concepts to understand if they are: synonymous with, different but with overlaps, or subsets of revealing.

The earliest reference to free knowledge sharing was put forward by Allen (1983), who coined the term the 'collective invention'. Collective invention refers to the free exchange of innovative knowledge among firms in the industry (Allen, 1983; Nuvolari, 2004). Allen (1983) provides examples from the early 19th-century iron and steel industry in Britain demonstrating that players, including competitors, shared information such as new techniques and plant designs to create rapid advances for the industry. Nuvolari (2004) provides examples from the Cornish mining industry to demonstrate the same concept.

Table 2-1: Concepts similar to revealing

Concepts	Key characteristics	Published papers
Collective invention	Share knowledge externally without monetary incentives Free from ownership rights Knowledge is a by-product of routine operations – no separate investment required to create	(Allen, 1983; Nuvolari, 2004; Nuvolari & Sumner, 2013)
[Voluntary] spillovers	Free knowledge flow from one party to another Usually involuntary, but can be voluntary Voluntary spillovers occur with patenting and during collaboration.	(Harhoff et al., 2003; Jaffe, 1986; Montoro-Sánchez et al., 2011; Sarkar, 2017b)
Knowledge disclosure	Voluntary, free and open knowledge flows from firms Knowledge disclosed is a public good Found in publications, conferences and online publications (internet)	(Boudreau & Lakhani, 2015; Muller & Pénin, 2006; Pénin, 2005)

The knowledge shared in collective invention is not the output of the firm's R&D, but rather the by-product of routine operations intended to increase the firm's productivity (Allen, 1983; Nuvolari, 2004). In other words, firms have not specifically invested to create the knowledge they share. This is one of the key motivators for firms to share knowledge in the first place, making the absence of pecuniary return for the shared knowledge immaterial. Under these circumstances, collective invention refers to a knowledge outflow from the firm that is non-pecuniary and as such, the principles underlying collective invention align with those for revealing. However, collective invention is a subset of revealing, rather than synonymous with it due to the nature of the knowledge shared, as revealing can involve knowledge outputs from

both operational (See Alexy, George, & Salter, 2013; Harhoff, Henkel, & von Hippel, 2003; von Hippel & von Krogh, 2006) and R&D processes (see Alexy, George, & Salter, 2013; Dahlander & Gann, 2010; Henkel, 2006).

Spillovers is a term used in R&D economics, innovation networks and other schools of literature to refer to any form of *overflow* or *leakage* of knowledge from the firm. It is generally understood as an unintentional flow of knowledge from one party to another, especially in network contexts (Ko & Liu, 2015). However scholarly work on R&D management, joint ventures, and distributed innovation systems also reports spillovers that are 'voluntary' and 'purposeful' (Dumont & Tsakanikas, 2001). Voluntary spillovers are fundamentally different from the inevitable knowledge diffusion that occurs in networks (Ko & Liu, 2015; Over-Smith & Powell, 2004), patenting (Jaffe, 1986) and during collaborations (Montoro-Sánchez et al., 2011) where the knowledge owner intends to share the knowledge via such means (e.g. see Allen, 1983; Bhattacharya & Guriev, 2006; Harhoff et al., 2003; Lhuillery, 2006; Nuvolari, 2004). For example, patents inevitably make knowledge a public good in exchange for proprietary rights that firms can exploit as revenue paths. However, if firms patent as a defensive mechanism – disclosing simply to claim ownership – and do not wish to appropriate the resultant knowledge, spillover is voluntary, purposeful and free – as the firm holding the patent is not motivated by financial incentives to make the knowledge a public good; rather it was the sole intention.

A significant aspect of spillovers is that knowledge is distributed without the need for codification (Sarkar, 2017b). Therefore, spillovers are difficult to monitor or block from distribution, and hence voluntary spillovers are viewed as knowledge that firms have 'given-up right to', thereby making it a public good – or in other words, the basic premise of free-revealing (Harhoff et al., 2003; von Hippel, 2005a).

The knowledge disclosure that occurs in R&D economics describes knowledge that is voluntary, free of charge, and open, i.e. firms do not restrict access to the disclosed knowledge (Pénin, 2007). Disclosure occurs in publications, conferences and through the internet (Muller & Pénin, 2006; Pénin, 2007). The literature on knowledge disclosure specifies that the receiver has no contractual obligation to pay for the knowledge – declaring that such knowledge is a gift (Pénin, 2007). Furthermore, in this type of disclosure, the disclosed knowledge carries no Intellectual Property (IP) rights that restrict access to or use of the knowledge (Boudreau & Lakhani, 2015). Hence, the disclosed knowledge is intended for reuse by the recipients (Boudreau & Lakhani, 2015). The non-pecuniary benefits of such knowledge flow occur only

if the knowledge is reused. While revealing does not specify a requirement for reuse, the research shows the benefits of revealing also depend on reciprocation and reuse (e.g. Harhoff et al., 2003)

As summarised in Table 2-2, the reviewed literature shows the three concepts are interconnected and share similar underlying assumptions and principles to revealing. However, revealing goes beyond these concepts to include knowledge flows that are restricted to a few recipients, and knowledge that is not necessarily public good (e.g. Alexy et al., 2013; Bogers, 2011; Harhoff et al., 2003; Henkel et al., 2014; von Hippel, 2005b). Therefore, like OI, revealing to can be considered an 'umbrella term' that covers any knowledge outflow that satisfies the four criteria outlined in the definition above (c.f. Huizingh, 2011).

Table 2-2: Overlaps and differences with revealing

Concept	Similarities to revealing	Specific differentiating characteristics
Collective invention	(1) Originates from a firm (2) Intentional and purposive, (3) Penetrates firm boundary, and (4) Does not generate immediate financial revenues for the firm.	Knowledge is specific to operational routines Creates public good No IP rights attached
Voluntary spillovers		Knowledge not codified – specifically related to technical knowledge Creates public good
Knowledge disclosure		Creates public good Only open access – cannot be restricted to a few No IP rights attached Benefits depends on reuse of knowledge

As well as the concepts discussed above, extant scholarly work gives rise to a variety of types of revealing. The next section reviews such revealing types to understand their relationship to revealing.

2.1.2 Variation in revealing implementation – four revealing behaviours

Extant literature indicates that revealing comes in different types and forms (Table 2-3).

Table 2-3: Different perspectives of revealing

Grounded in	Perspective	Mechanisms of revealing reflected in the literature	Example papers
Knowledge spillovers	Free-revealing	Patents, contributions to creative commons	(Harhoff et al., 2003; von Hippel, 2005a)
Open source software	Selective-revealing	Source code contributions (Open source)	(Alexy et al., 2013; Henkel, 2006; West, 2003)
Knowledge disclosure	Open disclosure	Scientific publications, conference proceedings, internet publications, source code contributions (Open source)	(Allen, 1983; Pénin, 2005)
	Closed disclosure	Research joint ventures, collaborative innovations	(Bogers, 2011; Lhuillery, 2006; Schweisfurth et al., 2011)

Free-revealing (Harhoff et al., 2003) and selective-revealing (Henkel, 2006) demonstrate variation in the selectivity, or lack thereof, of the knowledge content revealed. Knowledge disclosure gives rise to open and closed forms of disclosure differentiated based on the access granted to the knowledge (Muller & Pénin, 2006; Pénin, 2007). Different forms and types add richness to the concept of revealing, but the lack of a coherent framework integrating these differences hinders theory development due to ambiguities and inconsistencies in defining and operationalising the concept (cf. Huizingh, 2011). Synthesising the different types indicates that revealing can be arranged along two dimensions – the amount of knowledge content revealed, and access to revealed knowledge. The following section discusses how these dimensions contribute to the identification of the four revealing behaviours used by firms to systematise the implementation of revealing.

Free- and selective revealing are terms grounded in the open source software innovation and user innovation literature and refer to purposive sharing of internal knowledge with outsiders. Harhoff et al. (2003) define 'free-revealing' as "voluntarily giving up the intellectual property (IP) rights attached to the knowledge and granting access to all interested parties, making the information a public property" (p. 1753). 'Selective revealing' (Alexy et al., 2013; Henkel, 2006; Henkel, Schöberl, et al., 2013), on the other hand, describes the voluntary waiving of exclusion rights to *some* of the IP rights of an innovation (Henkel, 2006; Henkel, Schöberl, et al., 2013). Essentially, free- and selective revealing both create public good where the revealing firm does not retain rights or the power to control how the knowledge is accessed – and by whom. However, the knowledge flow is deliberate, goes across the firm boundary and the knowledge owner does not receive immediate revenue from it. Therefore, both fall under the definition of revealing applied in this study.

However, in selective revealing, the firm makes a conscious decision about which knowledge content is to be 'revealed' (Henkel, Schöberl, et al., 2013). Accordingly, free- and selective revealing are two behaviours of revealing and the distinguishing characteristic seems to be the 'amount of content'. The literature on both free- and selective revealing is not explicit on the yardstick for measuring the level of content (how much is all?). Rather it only explains the basis of differentiation, in that selective-revealing involves a conscious decision concerning selectivity of content to be revealed, whereas free-revealing involves no intentional effort to be selective.

However, clear motivational differences for why firms will opt for one or the other have been identified. Henkel et al. (2013) argue that relinquishing the IP rights for strategically selected

aspects of an innovation may increase efficiency and effectiveness of the R&D efforts of a firm by encouraging co-development and standardisation. Selective revealing "… implies that the focal actor does not reveal out of principle but rather as a result of weighing the commercial pros and cons" (Henkel et al., 2014, p. 2). Furthermore, the modularity of knowledge often associated with selective revealing can provide additional incentive for revealing (Henkel & Baldwin, 2009). Modularity allows the knowledge to broken down into smaller independent parts -modules. Selected modules can be revealed without affecting the others. Free revealing, in contrast, is driven by more altruistic intentions (Henkel et al., 2014). Firms that free-reveal do not expect immediate benefits to the firm, but rather focus on collective benefits such as industry advancements, and collective learning (Harhoff et al., 2003; von Hippel, 2005a).

The knowledge disclosure literature (Bogers, 2011; Lhuillery, 2006; Muller & Pénin, 2006; Nuvolari, 2004; Pénin, 2007) presents two key distinctions that differentiate revealing behaviour depending on selectivity in terms of access to the revealed knowledge. 'Access' can be open or closed. 'Open' knowledge disclosure must be voluntary, 'free of charge' and open to anyone, thus it creates public good (Pénin, 2007). With open disclosure there is control of how the knowledge is accessed once disclosed – and by whom. 'Closed' disclosure is voluntary and free but access is restricted to a selected group (Muller & Pénin, 2006; Pénin, 2005, 2007), similar to the knowledge exchange that occurs in collaborations with selected parties (Bogers, 2011). These collaborations are formed between carefully selected partners to achieve common and mutually beneficial goals in innovation. In closed disclosures therefore, access to knowledge is controlled.

Based on the two dimensions – amount of knowledge content and access to revealed knowledge – four behaviours of revealing are derived, as shown in Figure 2-2. No such classification of revealing behaviours is currently available in the literature to date. One could argue that the behavioural matrix provides an oversimplified and overly abstract view of a complex phenomenon. While it is understood that these behaviours do not have concrete boundaries, such simplifications of phenomena provide a starting point for empirical studies and theory building to develop further insights (e.g. Chan & Husted, 2010; Dahlander & Gann, 2010; Henkel et al., 2014; Huizingh, 2011b; Husted & Michailova, 2010). As with the arguments for OI as a continuum, (Dahlander & Gann, 2010), revealing too can be considered a continuum where the degree of openness varies. The four behaviours are discussed in detail in the succeeding sections.

		Amount of knowledge revealed	
		Not-selective	*Selective*
Access to the knowledge revealed	*Unrestricted*	Extreme revealing	Content-controlled revealing
	Restricted	Access-controlled revealing	Restrictive revealing

Figure 2-2: Four behaviours of revealing

Extreme revealing refers to revealing behaviours that do not restrict access or limit the content being revealed. Hence, extreme revealing can be considered the most open form of revealing. Firms that adapt open source (OS) principles (not just software firms, but any firm) exhibit such revealing behaviours in practice (see Raasch et al., 2009; Schweisfurth et al., 2011 for examples of application of OS principles in non-software contexts). Extreme revealing behaviour contributes to public good creation through the revealing activities because access to the knowledge is not controlled by the revealing firm. However, this does not mean that the firm operates without metaphorical walls to protect their core knowledge or economic base. On the contrary, extreme revealing means that firms do not actively restrict access to the knowledge, nor exercise secrecy or other forms of protection to prevent any content from being revealed.

Content-controlled revealing demonstrates purposive control of the amount of knowledge revealed. This revealing behaviour adapts the principles of selective-revealing (Henkel, 2006; Henkel et al., 2014) on the basis that some knowledge layers of an innovation may deliver more value in generating income than through revealing (Nuvolari, 2004; Nuvolari & Sumner, 2013). Conversely, some firms find revealing selected knowledge more beneficial that others (Henkel, 2006). For example, in OSS, some source code can be relevant to a firm's specific products or features that other firms may not have use for, but the source code is nevertheless of high commercial value to the originating firm. Revealing source code may not deliver significant benefits to the firm because its value depends on a high reuse rate (Henkel, 2006). In such instances, firms strategically select the knowledge layers to reveal for non-pecuniary benefits and capitalise on others to generate income. Therefore, selectivity of knowledge for content-controlled revealing assists firms to identify and reveal the components that can potentially deliver valuable inputs to the firm.

Access-controlled revealing purposively restricts access to the knowledge revealed. Such behaviour exists in collaborative partnerships with a selective group of participants (Bogers, 2011; Pénin, 2007; Pisano & Verganti, 2008). While the partners who receive the knowledge

are deliberately selected, the size of the group depends on the firm and their requirements. The partners can be individuals or firms (e.g. von Hippel, 2005a), or larger networks (Pisano & Verganti, 2008). An example of access-controlled revealing is when firms take on interns or personnel from other organisations, providing them unrestricted access to the firm's knowledge (Muller & Pénin, 2006; Pénin, 2007). While there may be physical restrictions in place that limit access to documents, locations, and discussions, the host firm is unable actively control the amount of knowledge being accessed by these individuals/groups when spending time in the firm.

Finally, *restrictive revealing* purposively controls both the amount of knowledge and access to revealed knowledge. From a firm's perspective, restrictive revealing behaviour can be argued as the most manageable type of revealing. Hence this form of revealing is commonly found in most R&D active firms. As required for OI, firms that innovate have to take in knowledge (Chesbrough, 2003a) that may require them to share some internal knowledge with the external source. In such instances, especially when there is uncertainty about the value of returns, firms may adapt restrictive revealing behaviour to reveal only what is required to the identified parties. For example, in the early stages of initiating collaborations, firms practice caution by being selective in the knowledge shared, especially when the knowledge is highly complex (technically or economically) and largely tacit in nature (Lhuillery, 2006; Norman, 2002). Firms that are highly protective of their internal knowledge use restrictive revealing, even when non-disclosure agreements (NDAs) are in place (Sarkar, 2017b).

In summary, the four behaviours derived from the extant literature indicate variation in the implementation of revealing by firms. However, questions remain as to how these behaviours are implemented, and why. The rest of this chapter seeks to understand how revealing is practiced through the mechanisms of revealing, and the drivers and firm capabilities that influence its implementation.

2.2 Mechanisms of revealing

This section aims to understand the specific mechanisms used by firms to reveal knowledge. It reviews four key mechanisms identified through the literature to gain insight on the underlying theoretical perspectives and assumptions. First, the existing literature that discusses the mechanisms of revealing is outlined. Through this, four mechanisms representative of revealing are identified – open source contributions, scientific publications, patents and

collaborative innovation. The section concludes with a detailed discussion on these four mechanisms.

Identifying the mechanisms of revealing is a critical step in understanding how revealing operates in practice. Several studies present discussions of the mechanisms used for revealing (e.g. Brunswicker & Chesbrough, 2018; Chesbrough & Bogers, 2014; Lhuillery, 2006; Pénin, 2007). Table 2-4 summarises revealing mechanisms, as identified through exemplar papers, which are discussed in full the latter part of this section.

Table 2-4 : Mechanisms of revealing

	Lhuillery (2006)	**Penin (2007)**	**Chesbrough and Brunswicker (2018; 2014)**
Open access	• Patenting • Source code publication (open source publications) • Scientific papers and publications	• Publications in journals • Conference presentations • Internet publications (incl. open source contributions)	• Contributions to commons or non-profits • Standardisation • Open source contributions
Restricted access	• R&D coordination • Research joint ventures • Standardisation • Technical committees	• Research joint venture • Training of employees from other firms • Personnel exchanges • Private meetings • Visits to factories	• Joint ventures

Lhuillery (2006) and Penin (2007) classify revealing mechanisms based on the level of access provided to the knowledge. While mechanisms such as patenting, publications and online publication including OSS contributions provide unrestricted access, collaborative setups such as joint ventures and personnel exchanges restrict access to knowledge. Chesbrough and Brunswicker (2014) do not classify mechanisms according to access, but parallels to the above form of classification can be identified in the mechanisms discussed. However, no similar classification can be applied to identify mechanisms that are selective in terms of the content they reveal. Selectivity with regard to knowledge is firm-dependant and so will not be reflected in the mechanisms of revealing.

An obvious concern when discussing mechanisms of revealing is differences in IP rights (IPR) that accompany some mechanisms. Even though it is common for all revealed knowledge to carry some form of IPR, it does not prevent the recipients from reusing the knowledge for learning, especially if the knowledge is in the public domain. In general, some IPR are established to promote sharing and reuse. For example, knowledge published on websites (blogs, wikis, etc.) carries creative commons licenses that promote free redistribution and

reuse. Among the mechanisms of revealing that carry IPR, patents present a significant conundrum. Patents essentially reveal knowledge to the public domain in exchange for exclusive rights that prevent imitation and replication. However, there are possibilities for reuse, and derivations and modifications.

Table 2-5 cross references access and IPR factors to identify the specific mechanisms that correspond to each category.

Table 2-5 : Mechanisms of revealing based on IPR

		Access to knowledge	
		Open	*Restricted*
Exclusive rights to revealer	*No*	Open source contributions Publications	Collaborative innovation
	Yes	Patents	Secrecy

Similar categorisation of mechanisms cannot be achieved based on the amount of knowledge revealed (the other dimension of revealing behaviours). Restriction of the amount of knowledge revealed is not reflected in the mechanisms used by firms. For example, firms exhibiting either extreme or content-controlled revealing can use publications as a mechanism. Therefore, based on the current understanding, introducing the dimension 'amount of knowledge' does not alter the categorisations presented in Table 2-4 or Table 2-5.

Four prominent mechanisms of revealing can be identified in the literature – Open source contributions, scientific publications, patents, and collaborative innovation. Table 2-6 presents a summary of the mechanisms.

Table 2-6: Mechanisms of revealing

Mechanism	**Characteristics**
Open source contributions	Includes the open source software and non-software (hardware, design, etc.) based contributions; Unrestricted access to the revealed knowledge; public good creation; Selectivity in knowledge can occur. (Alexy & Reitzig, 2013; Henkel, 2004, 2006; Lakhani & Wolf, 2003; Raasch et al., 2009; von Hippel & von Krogh, 2003)
Scientific publications	Publishing in academic journals, conferences or other technical publications; Unrestricted access to all; public good creation; Selectivity in knowledge unclear. (Hicks, 1995; Jansen, 2010; Latour & Woolgar, 1989; Pénin, 2005; Simeth & Lhuillery, 2015)

Mechanism	Characteristics
Patents	Publishing novel technical knowledge in exchange of exclusive rights; Unrestricted access to all; knowledge is public but reuse restricted; Selectivity in knowledge – only knowledge with unique qualities can be patented. (Bloch, 2013; Jaffe, 1986; Jaffe et al., 2000; Lhuillery, 2006; von Hippel & von Krogh, 2006)
Collaborative innovation	Includes joint ventures, strategic alliances, user innovation; formal or informal; Considers only the knowledge revealed within collaboration; Restricted access; collaborations are between a selected few; Selectivity in knowledge may or may not occur. (Baldwin & von Hippel, 2011; Bogers, 2011; Dodgson et al., 2008; Montoro-Sánchez et al., 2011; Mowery et al., 1996; Pisano & Verganti, 2008)

OS contributions are the most widely known, studied and accepted form of revealing. Scientific publications and patents have long been used to share knowledge in the public domain within a formalised structure. Collaborative innovation refers to both formal and informal innovation efforts that are limited to, or targeted at a specific group, and include joint ventures, R&D collaborations, mutual exchange of personnel, material and expertise, and even user innovations, among others. The following sections present these mechanisms in detail.

2.2.1 Open Source Contributions

The concept open source (OS) innovation emerged in the early 1980s in the software industry (Pénin, 2007; von Hippel & von Krogh, 2003). In the early days, computer software was predominantly developed by scientists or engineers who freely shared the codes with the community. However, the landscape of software development changed in the 1980s when institutions such as Massachusetts Institute of Technology, USA, where significant software development was taking place, began to licence the software for commercial purposes (von Hippel & von Krogh, 2003), which prevented even the developers from being able to access the source code[10]. In order to counteract the surge in appropriation behaviour, and to preserve the free-sharing 'hacker culture'[11], Richard Stallman established the Free Software Foundation

[10] Source code is a sequence of instructions that includes a series of instructions to be executed by the computer along with a description of what the code is for, which enables the other users to identify and understand the codes. When converting these codes into a computer legible program, a 'compiler' converts the codes into binary format. When licensing the software, the binary version will be released, preventing others from using or accessing the source code (Harhoff et al., 2003; Moerke, 1999; Simon, 1996).

[11] The culture of freely sharing source codes and other related information among the developers associated with software development, who are often referred to as 'hackers' to identify very talented and dedicated programmers (von Hippel & von Krogh, 2003).

(FSF), which introduced the General Public License (GPL), otherwise known as the 'copyleft' – a play on the term copyright. It gave the developers the right to provide free access to source codes, and also enabled the users to develop, modify and redistribute codes, but not for commercial gain (von Hippel & von Krogh, 2003). Any software developed within FSF was always free to use (e.g. the Linux operating system (von Hippel & von Krogh, 2003).

Open source software (OSS) is an extension of the free software movement (Raymond, 1999) where the source code is still 'free', but the machine readable compiled software can be sold for a fee (see Perens, 2008). In the software industry, OS principles mandate royalty-free redistribution of source code to allow derivations and modifications of the same among other criteria (opensource.org, 2007). Essentially, this means the source codes are positioned in the public domain and thus, free to access (Kogut & Metiu, 2001; Perens, 2008; von Hippel & von Krogh, 2003). It provides the 'freedom' – a notable distinction in the meaning of the word 'free' used in OS – essential for users to reuse, modify or further develop the source code.

The term open source has now evolved to a stage where it refers to the model of intellectual property rights attached to the software, which is independent of who is involved in the development (von Hippel & von Krogh, 2003). The source codes of commercial software that is intended to generate economic incentives are accessible only to the internal employees (Lerner & Tirole, 2002; M. H. Meyer & Lopez, 1995). In contrast, in open source software, the source code is accessible to anyone interested (von Hippel & von Krogh, 2003).

The application of OS principles is no longer limited to software (see for example Raasch, Herstatt, & Balka, 2009). The OS design concept is gaining popularity in practice. Over the years, various studies have claimed the OSS model as exemplary of the private-collective model (Alexy & Reitzig, 2013; von Hippel & von Krogh, 2003, 2006). In fact, the OS based innovation model can co-exist with the traditional proprietary model of innovation (Pénin, 2012; von Hippel & von Krogh, 2003). Therefore, the application of OS contributions in non-software-based contexts is not surprising. It is arguably challenging but beneficial to reap both pecuniary and non-pecuniary benefits. A recent example for the non-software application of OS contributions is the release of patents relevant to electric car manufacture held by Tesla motors (Karamitsios, 2013; Ohnsman, 2014; Voyles, 2014). Tesla announced that the patents are royalty-free for the purposes of use, modification and redistribution. In the local context,

Open Lab in Wellington, New Zealand provides an open space for multiple academics and professionals to get together and develop open designs for the creative industry[12].

A key reason for firms to engage in open source contributions (software or otherwise) is that the derivations and modifications of the knowledge can be of direct benefit to the revealer. As the innovators, a firm can better absorb any new knowledge that is developed based on the revealed knowledge, compared to others. Secondly, OS contributions provide the firm the opportunity to engage in collective-learning (Lakhani & Wolf, 2003; Raymond, 1999). For example, software developers gain satisfaction and learning when writing code. In return, the users of code test, debug and validate such code (Henkel et al., 2014). Not only do these external users help the revealing firm to test and debug the new code faster, the revealing firm learns through interaction and communication with the OSS community. Reputation gain is another outcome of OS contributions (Harhoff et al., 2003; Lakhani & Wolf, 2003). During redistribution, the open source principle requires the users to cite the initial developers in each release, similar to the practice of citation in academic publishing. More source code development citations signify higher quality knowledge, as well as providing validation of the developer's knowledge capabilities.

2.2.2 Scientific Publications

Publishing scientific and technical papers was one of the earliest mechanisms for sharing knowledge (Hicks, 1995; Jansen, 2010). Publishing allows firms to manipulate the private and public nature of the knowledge modules, i.e. control which knowledge modules are to be revealed and which to keep private relevant to an innovation.

Publications are the codified form of scientific and technical knowledge that emerges or is created through in-house research activity. Therefore, publications necessarily convey 'explicit' knowledge (Polanyi, 1966), but are also important indicators of the 'tacit' and unpublished knowledge that exists within firms which provide "the foundation of scientific and technical credibility" for a firm (Hicks, 1995, p. 402). In order to convey such information effectively, firms that publish require specific capabilities. The firm needs to understand the scientific community sufficiently to identify the field to which they can contribute, be able to express the technical and scientific details in a commonly understood yet academically rigorous

[12] Open Lab is an initiative by Massey University in Wellington to encourage academic-industry collaborations through open design (http://www.openlab.ac.nz/about/our-story/)

manner, and be able to construct theoretical arguments integrated with empirical evidence to support the claims made (Simeth & Lhuillery, 2015). Since firms need to think ahead and invest in building such capabilities for use in the future (Cohen & Levinthal, 1994), not all organisations can engage in scientific publications.

Due to the high uncertainties in innovating (Jalonen, 2011), firms need to proactively convince potential adaptors of the merits of their innovations. Publishing is used in such situations as a means of communicating, as well as validating the novelty and rigour of innovations (Polidoro Jr. & Theeke, 2009). Furthermore, publishing is also a defensive strategy for firms. In highly competitive and fast moving industries, innovations are published as a prequel to patents (Hicks, 1995; A. J. Nelson, 2009; Ponce, 2011) to 'lock in' the innovation. On the other hand, in some industries, firms publish as an alternative to patents due to rivals being able to innovate around less technically challenging innovations (Johnson, 2014).

A significant benefit of publishing is the reputational gains. Publishing indicates the existence of 'technically knowledgeable people' (Hicks, 1995). Therefore, firms encourage publishing to attract researchers that are significantly involved in research networks (Frederiksen & Husted, 2002). For example, firms that publish more scientific knowledge will be perceived as possessing the capability for rigorous and verifiable innovation activity and therefore attract more collaboration and joint innovation approaches from other firms. Most publication endeavour tends to be cross-institutional (Frederiksen & Husted, 2002), indicating collaborative effort in generating scientific and innovative knowledge. These collaborations are formed based on the credibility of the participants (De Meyer, 1993; von Hippel, 1989).

Credibility reflects to the 'scientists' ability to do science' (Latour & Woolgar, 1989), which means the ability of the researcher to develop internal knowledge. Such abilities inevitably involve assimilating and applying external information when conducting research. According to the credibility conversion cycle (figure 2-3), data that researchers acquire from both internal and external sources is used to build arguments that will be presented and advanced through publications. These publications would build the recognition necessary to raising funding for equipment and/or material required to produce the data or knowledge (Hicks, 1995; Latour & Woolgar, 1989). Thus, publishing builds and maintains credibility, and so is an innate component of the research agenda of a firm.

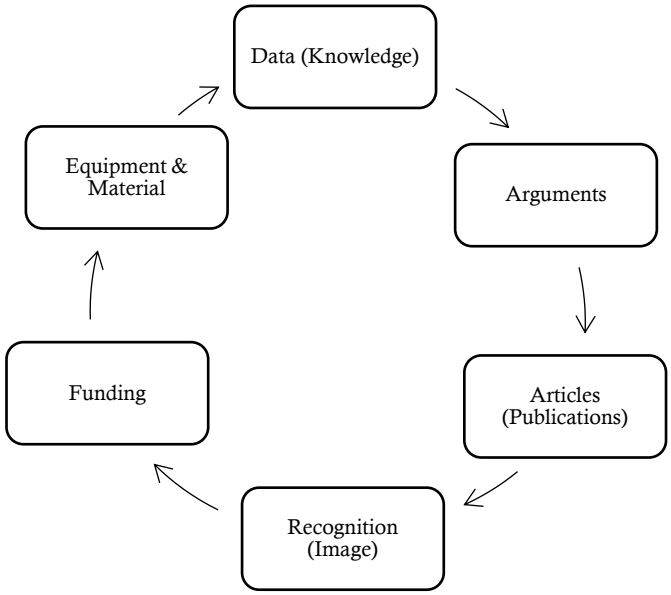

Figure 2-3 : Credibility conversion cycle. Adapted from Latour, B., & Woolgar, S. (1989). Laboratory Life: The Construction of Scientific Facts. Princeton University Press

2.2.3 Patents

Patenting is conventionally associated with pecuniary motivations (Cohen et al., 2000). However, a number of scholars point out that not all patents carry the motive of revenue (Bloch, 2013; Cohen et al., 2002; Jaffe, 1986). Among other IPR protections, patents are the strongest form that grants exclusion rights (Bhattacharya & Guriev, 2006). IPR protection provides exclusive rights for use of the innovation to its producers for a limited period of time (Pakes & Griliches, 1980). However, the word 'patent' originates from the Latin word '*patere*' which means 'to lay open' While the innovative knowledge conveyed through a patent is open to all without restrictions, the use of the innovation is restricted to the owner.

Patents generally cover products or processes that contain 'new' functional or technical aspects, such as for how things work, how they are made, and what they are made of. The knowledge disclosed through a patent should be comprehensible to the user, with sufficient background provided to understand and recreate the innovation. But the IP protection prevents others from making and selling the innovation. However, from a knowledge sharing perspective, patents do not prohibit learning from, reusing, modifying and deriving new knowledge from the innovation. Even though innovators obtain patents to protect intellectual rights, they may be sold, licensed, mortgaged, assigned, transferred, given away, or simply abandoned (for example, see the opening case in Alexy & Reitzig (2013)).

In most studies, patenting is considered a method of output for the R&D task (Basberg, 1987) at the development stage of an innovation. Basberg (1987) further shows that not all patented inventions are innovated (figure 2-4). This indicates that patents not only reveal knowledge pertaining to successful research activity that culminated in a commercialised product, but also knowledge pertaining to research activity that is not applied, and thus remains as research knowledge.

Firms may obtain patents to prevent competitors from using an invention rather than with the intention of commercialisation (Basberg, 1987; Cohen et al., 2000), a strategy known as 'patent blocking' (Cohen et al., 2000), and the most widely accepted reason for patenting (Basberg, 1987; Cohen et al., 2000; Levin et al., 1988). Apart from patent blocking, other reasons for patenting identified by Cohen et al. (2000) are to prevent copying of an invention, to enable revenue generations through licensing (economic benefits), as a means of strengthening a firm's position in negotiations (such as in cross-licencing), to prevent infringement suits, to enhance reputation and as a measure of the firm's performance, among others. However, interestingly, using patents as a measure of the technological performance of a firm or as an avenue for revenue generation avenue are rated as the least important reasons. Furthermore, gaining access to certain foreign markets – a motive that is remotely connected to appropriation, was put forward by Levin et al. (1988) as another reason for patenting.

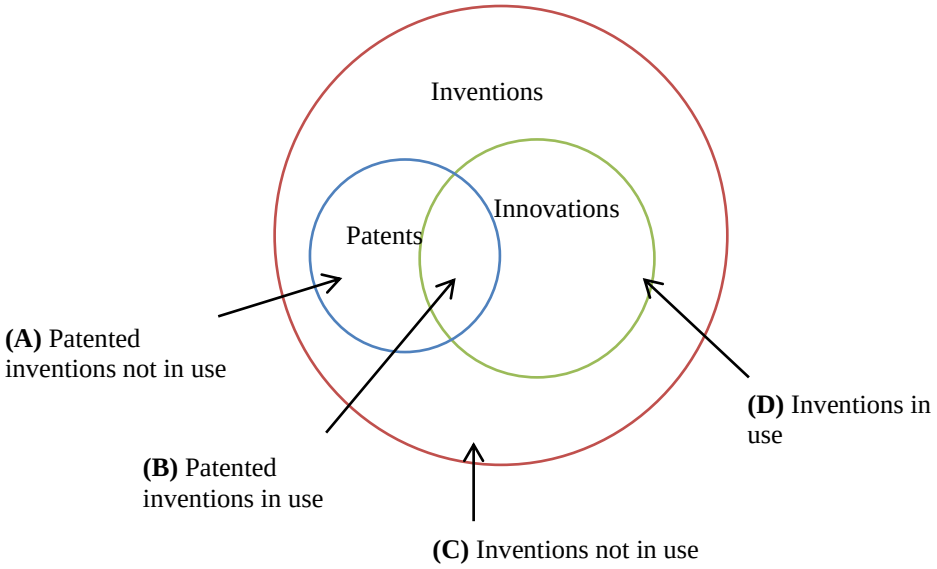

Figure 2-4. A generalised diagram of relationships between patenting, inventions and innovations. Adapted from Basberg, B. L. (1987). Patents and the measurement of technological change: A survey of the literature. *Research Policy*, *16*(2–4), p. 133.

Furthermore, patenting patterns are not identical across all industries. Industries involved with chemical products such as pesticides, drugs and pharmaceuticals and industrial organic

chemicals as well as uncomplicated mechanical equipment industries tend to benefit more from patents preventing imitations comparative to other industries (Cohen et al., 2002; Levin et al., 1988). The reason for such a distinctive behaviour in patenting in the chemical industry is due to the existence of established standards to validate a patent and defend against infringements in a court (Levin et al., 1988).

Patents as measures or indicators of knowledge spillovers have been studied and discussed in detail by many scholars (Bloch, 2013; Cohen et al., 2002; Jaffe, 1986, 1988; Jaffe et al., 2000). For example, there are no direct financial benefits for firms from the knowledge disclosed through patents unless the user of the knowledge is applying it for a commercial purpose and thus requires a licence. The restriction on re-use does not prevent users from accessing the knowledge and learning from it, or further developing the disclosed knowledge. Therefore, rather than preventing revealing (von Hippel & von Krogh, 2006), patenting facilitates it.

2.2.4 Collaborative innovation

Firms collaborate with others – firms, institutions or individuals – to share expertise, knowledge and resources and to jointly seek solutions to product or service issues. Joint ventures (see Powell, 1998; Powell, Koput, & Smith-Doerr, 1996), strategic alliances (Mowery et al., 1996; Muthusamy & White, 2005), and user innovation, especially *lead-user* innovation (Baldwin & von Hippel, 2011; von Hippel, 2005b), are among the most commonly used and referenced forms of collaborative innovation.

Collaborations are generally focused on technological innovations (Dodgson et al., 2008). Dodgson et al. (2008), further argue that firms collaborate to achieve benefits they cannot achieve individually, thus ‘positive sum’ gains (2008, p. 148) are made in terms of increased scale and scope of innovations, shared cost and risk, and increased capacity to deal with complexities (Dodgson, 1992; Dodgson et al., 2008). Collaboration has the further advantage of convenience in terms of governance. Mergers and acquisitions, which are both means of accessing external expertise, knowledge and skills, can be tedious and hard to terminate once the commitment has been made (Dodgson et al., 2008). Therefore, collaborations such as joint ventures or strategic alliances are less-binding alternatives. Furthermore, collaborations are useful in dealing with rapid changes and uncertainties in the environment (Jalonen, 2011). Collaborating on innovations makes it easier to meet consumer demands and accommodate unpredictability than attempting to do the same in isolation (Dodgson et al., 2008) because it

provides access to a larger base of expertise and skills (Dodgson, 1992), sometimes including the users and consumers concerned as well.

Collaborations are formed to gain mutually beneficial outcomes (Ketchen et al., 2007) for all participants. Some collaborations are formed and maintained based on the understanding they are essential to capturing a significant share of the economic value of an innovation. For example, Nokia has a network of over 300 small high-tech firms collaborating with it for innovation, and there are mutual benefits created through this rich ecosystem (Ketchen et al., 2007). Some collaborations provide robust platforms for basic and applied research knowledge (Sáez et al., 2002). Collaborations with universities/research centres provide access to basic, generic and pre-competitive research based knowledge (Sáez et al., 2002). Collaborations with competitors or firms in other industries provide access to knowledge that is more specific and directly focused on problem solving, thus facilitating product designs and development (Sáez et al., 2002). This is more commonly known as applied research knowledge.

Collaborations can be open in two aspects – one is the outcome (Baldwin & von Hippel, 2011), and the other is the network – or terms of participation (Pisano & Verganti, 2008). Baldwin and von Hippel's version of open collaboration encompasses projects involving contributors who share the work of designing innovations and also reveal the outcomes in the public domain, one example being the open source software industry (Baldwin & von Hippel, 2011). Contributors in such efforts are not rivals competing against the design[13], and they have no intention of collectively or individually selling the innovation or the intellectual property rights attached to it (Baldwin & von Hippel, 2011).

Collaborations generally encounter unpredictable outcomes and therefore are heavily reliant on mutual trust, commitment, honesty, and equitable treatment in recognition of the interests of all parties involved (Ketchen et al., 2007). Therefore, partner selection plays a critical role in collaborations (see Li et al., 2008). Pisano and Verganti (2008) distinguish between collaborations based on the openness of participation (network). While open collaborations pose no restrictions to participation (e.g., idea challenges), closed collaborations are strictly formalised and structured in order to share resources and risk, and achieve complementarity in terms of goals for the project (Dodgson et al., 2008; Pisano & Verganti, 2008). In completely open collaborations such as crowdsourcing, any interested party can participate in the process

[13] A design is defined as the set of instructions required to produce the innovation (Simon 1981)

of the innovation. This could call for/involve contributors beyond customers, end users or suppliers to include universities, other industries (Bogers, 2011), research institutions (Bogers, 2011; Pisano & Verganti, 2008), students, inventors and even competitors (Pisano & Verganti, 2008). Furthermore, collaborations have become diverse over time in relation to intentions, nationalities of the participants, and the formal structures of collaboration (Gulati & Singh, 1998).

In either form of collaboration, firms share some form of internal knowledge to enable the combining of resources and complementarities for mutual benefit (Bogers, 2011; Husted & Michailova, 2010). The four main types of knowledge exchange in collaborations are: (1) *Background knowledge* is the existing knowledge in firms, which is contributed to the collaborations; (2) *Foreground knowledge* refers to what is created as an outcome of the collaborative task; (3) *Sideground knowledge* is the knowledge relevant to the task developed in-house in parallel with the collaboration; and (4) *Postground knowledge* is developed in-house post-collaboration (Bogers, 2011).

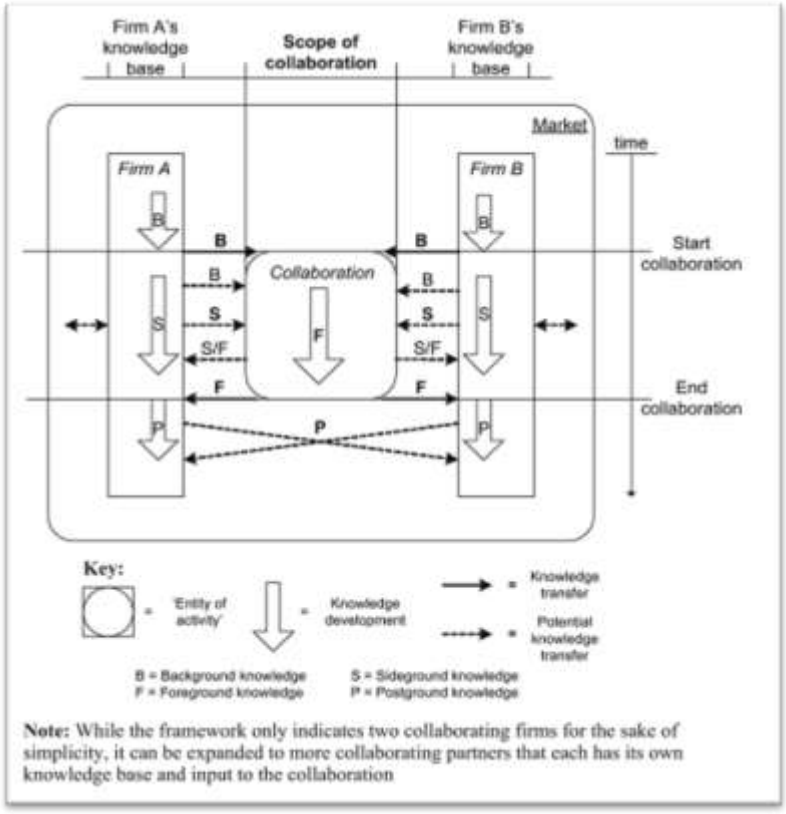

Figure 2-5: Framework for knowledge development and transfer in collaborations. Reproduced from Bogers (2011).

Revealing in a collaboration can occur when sharing 'background' or 'foreground' knowledge (Baldwin & von Hippel, 2011; Bogers, 2011). As shown in Figure 2-5, the background

knowledge that is transferred to the collaboration is revealed free by one participant to other participants in the task (Bogers, 2011). Such knowledge is critical and influential in generating the foreground knowledge. The foreground knowledge can be protected (patenting, trademarks, etc) (Bogers, 2011; Hurmelinna-Laukkanen, 2011), kept secret (non-disclosure agreements), and/or openly revealed (Bogers, 2011).

Collaborations may encounter appropriation issues due to the multiple and diverse nature of participation. They therefore require some kind of protection (Hurmelinna-Laukkanen, 2011) for foreground knowledge. However, this method of protection does not necessarily have to be through a conventional IPR approach, but can be the equivalent of the 'copyleft' protection associated with open source software projects (Lakhani & von Hippel, 2003). However, due to complexities in defining ownership of foreground knowledge, this thesis research finds relevance only in background knowledge revealing within the context of collaborations.

In summary, this section reviewed four key mechanism used in firms that has non-pecuniary knowledge outflows. These mechanisms are the observable aspect of revealing in firms. however, mechanisms alone do not provide insights to the type of revealing implemented, the rationale for doing so or the process of implementation within a firm. The following sections aim to understand why firms reveal and the aspects of firms that contribute to the implementation of the revealing.

2.3 Why do firms reveal?

This section presents the factors that influence revealing in firms. First, an explanation is provided for why firms engage in revealing when the knowledge outflow does not create financial incentives. This is followed by a review of the relevant literature to understand the drivers for revealing and the influence of firm capabilities. The drivers explain what motivates firms to reveal. This section also explores the influence of potential outcomes, firm characteristics and external pressures on revealing.

The value of knowledge is a key source of competitive advantage for firms (J. Barney, 1991; Nonaka, 1994) that depends on the extent to which it is proprietary (Polidoro Jr. & Theeke, 2009; Polidoro Jr. & Toh, 2011). Therefore, basic economic theory suggests that firms investing private funds on innovating and creating propriety knowledge should generate tangible income (a monetary value) from this activity, i.e., by minimising intentional or unintentional spillovers (De Fraja, 1993; Muller & Pénin, 2006). However, firms that reveal knowledge go against this notion of exclusive proprietorship and voluntarily disclose all or

parts of knowledge to external parties including competitors, in exchange of benefits other than pecuniary gain. OI suggests that firms should open firm boundaries to allow some knowledge to flow out while appropriating other knowledge components. The underlying argument is that firms do not use all the knowledge that is created internally and therefore should allow some of it to be exploited externally (Chesbrough, 2003b, 2003a). Even if the firms appropriate the knowledge internally through patents, or other IP based mechanisms, unintentional spillovers are inevitable. Under these circumstances, purposive outflows may create value to the firm through non-pecuniary benefits (Alexy et al., 2013; Harhoff, 1996; Harhoff et al., 2003). The potential benefits of revealing are discussed in detail in Section 2.3.1.

Revealing knowledge to external parties, especially competitors, often comes with a cost to the firm (Pénin, 2005). There is a risk of increased competition when other companies in the same industry use the knowledge to increase their innovation portfolio. However, the absorptive capacity of a firm determines how and to what extent knowledge sourced from external sources can be applied and reused in the firm (Cohen & Levinthal, 1989). Furthermore, the externals must already possess or be able to create the necessary complementary knowledge to internalise the acquired knowledge (Cohen & Levinthal, 1990; von Hippel & von Krogh, 2006). Therefore, just because the revealing firm (revealer hereafter) makes the knowledge accessible to others, this does not mean competitors will be able to make better use of the knowledge than the firm that reveals it. Moreover, even if externals use the knowledge and improve on it, their subsequent knowledge creation and spillovers are of higher value to the revealer due to the cumulative and path dependent nature of the knowledge (Alexy et al., 2013; Cohen & Levinthal, 1990). Furthermore, the revealer already possesses the complementary knowledge, particularly tacit knowledge, required to understand and apply any subsequent knowledge created by the external users (Henkel et al., 2014; Hicks, 1995; Pénin, 2005).

The literature indicates two factors that influence the overall revealing activities of a firm – drivers to reveal and firm capabilities. First, drivers to reveal, namely, potential outcomes, firm characteristics and external pressures, influence the choice to reveal. Firms' choice to reveal depends on these drivers. Secondly, firm capabilities relevant knowledge resources affect revealing activities, either through enabling or limiting the capacities relevant to the activities. The following sections elaborate on these factors to illustrate current understandings.

2.3.1 Drivers of revealing

Whether or not to reveal is a decision that firms make weighing the trade-offs of non-pecuniary benefits vs. benefits of protection. As discussed in the preceding section, there are risks and vulnerabilities associated with revealing that may threaten the competitive advantage of firms (Frishammar et al., 2015; Ritala et al., 2018). Accordingly, there are specific driving forces behind firms' revealing choices. The main driving factor is the firm's requirement for revealing – which may be potential returns to the firm, the firm's characteristics (e.g. Gassmann, Enkel, & Chesbrough, 2010; Van Der Meer, 2007) or satisfying external pressures to be open and reveal (Harhoff et al., 2003; Henkel et al., 2014; von Hippel, 2005a). The following sections present and discuss the prevailing understanding on these factors.

2.3.1.1 Potential outcomes of revealing

Several key papers present empirical and anecdotal evidence for potential returns from revealing (e.g. Alexy et al., 2013; Harhoff et al., 2003; Henkel et al., 2014; Pénin, 2007; von Hippel, 2005b). These papers are grounded in different variations of revealing, as discussed previously in the chapter – e.g., selective revealing, free revealing, open disclosure, and so on. However, it is difficult to draw any definitive conclusions on outcomes due to the lack of clarity on their links with specific revealing behaviours. Table 2-7 presents the outcomes of revealing depicted in the literature, based on the general perspective of revealing they are grounded in. Several outcomes are common to both characteristics of revealing.

Table 2-7: Potential outcomes to the firm

Outcomes of revealing that is open to all	**Outcomes of revealing that is selective (content and/or access)**	**Outcomes common to all perspectives**
Standardisation and compatibility with complementary products Induce manufacturer improvements	Access to resources – shared costs in R&D	Avoid repetitive R&D efforts Reputation gains Reciprocating others' revealing efforts Eliminate costs of secrecy Accelerated diffusion and adoption of innovations
Contributing papers: *Open* - (Allen, 1983; Boudreau & Lakhani, 2015; Contreras, 2011; De Fraja, 1993; Harhoff et al., 2003; Nuvolari, 2004; Pénin, 2007; von Hippel, 2005a, 2005b; von Hippel & von Krogh, 2003) *Selective* - (Alexy et al., 2013; Grossman & Shapiro, 1986; Henkel et al., 2014; Lerner & Tirole, 2002)		

Avoiding repetitive R&D is an outcome that firms perceive to achieve through revealing. This was one of the motives for collective invention in the 1980s (Allen, 1983; Nuvolari, 2004). In the early 19th century steel industry, knowledge was freely shared to spread the costs of research

investment (Allen, 1983). Research at this time was expensive, largely publicly funded and carried out in academic institutes. Therefore, firms in the private sector reduced the cost of developing new knowledge and increased the rate of innovation by revealing knowledge. Such revealing efforts avoided the idiomatic 'reinvention of the wheel' - repetitive R&D efforts within the industry (Allen, 1983). It also created economies of scale in R&D efforts (Grossman & Shapiro, 1986), thus increasing the R&D productivity. Avoiding repetition in research is a key reason for scientific and industrial communities to share innovative knowledge via patents (De Fraja, 1993), publications (Hicks, 1995) and at conferences (Allen, 1983; Pénin, 2005) as well. For example, scientists involved in the Human Genome Project (HGP), in which more than 20,000 genes and chemical base pairs of human DNA were identified, revealed the sequential data through a knowledge commons portal named "Bermuda Principles" (Contreras, 2011). Revealing the identified DNA through the portal allowed better coordination among the research groups and awareness of newly discovered structures. The underlying intent was the rapid development of the science by investing efforts to discover the genes and chemical bases that were not discovered (Boudreau & Lakhani, 2013; Cook-Deegan & McCormack, 2001). Exerting proprietary rights that enforced secrecy over the findings from this project may have not resulted in any exclusive benefits for the scientists, nor would the project have been as successful due to wasted time and effort.

Table 2-8: Benefits of revealing. Adapted from Henkel et al. (2014, p. 885)

Marketing related
It opens more doors for our hardware because it allows for more custom solutions Cooperation with the open source community is good marketing We want to appear as a good player in the open source community Revealing good code is a signal of quality for our products
Technical reasons
We get better and faster testing and debugging It allows third parties to develop complementary software and hardware more easily It reduces our maintenance effort This way, our products stay compatible with other products Others develop the code further and reveal their developments in return We often do not have sufficient resources to make all developments on our own

Firms revealing to gain access to resources such as new knowledge or capabilities, is a key characteristic of collaborative innovation (Alexy et al., 2013; Bogers, 2011; Hicks, 1995; Simeth & Raffo, 2013). In the case of the steel industry, firms sometimes had to collaborate regardless of preference due to lack of the internal resources – either economic, technical or scientific –required for innovations (see Adner, 2006). Empirical evidence from OSS based industries (presented in Table 2-8) reports firms' claims that selective-revealing satisfies their

technical knowledge and capability requirements (Henkel et al., 2014). According to the empirical data, the firms in the sample relied on revealing to receive feedback from the community on their source code (Henkel et al., 2014). The feedback was provided in the form of debugging code, or by building on the innovation and then in turn, revealing the developments.

Credibility and reputational gain are the most commonly acknowledged outcomes of revealing in all its forms (Alexy et al., 2013; Harhoff, 1996; Harhoff et al., 2003; Pénin, 2007; von Hippel, 2005a). Most revealing effort requires some form of codification of knowledge, hence is explicit in nature. Such revealing provides an indication that the firm retains the tacit components of the knowledge (Hicks, 1995) which cannot easily be transferred. Furthermore, in some revealing practices, the revealed knowledge goes through a validation process (Hicks, 1995; Lakhani & von Hippel, 2003; Pénin, 2005), e.g., peer-reviewed publications, appraisal of patents, testing of source code. Therefore, by revealing innovative knowledge, firms create the credibility and reputation needed to support collaboration and access expert networks for future innovations (Muller & Pénin, 2006). These credentials help overcome partner uncertainty (see Hoecht & Trott, 1999; Li, Eden, Hitt, & Ireland, 2008), avoid coordination costs, and overcome others' unwillingness to collaborate.

Revealing assists accelerated diffusion and adoption of innovations. Revealing knowledge provides evidence of quality innovations in a firm (Henkel et al., 2014). Therefore, being the first to reveal an innovation increases the chances that the innovation will be extensively embraced (von Hippel, 2005a; von Hippel & von Krogh, 2006). Innovations that possess knowledge characteristics that are unique to the firm benefit from revealing through increased firm profits, due to the difficulty of imitating and accelerated introduction respectively. In industries where being the first to appropriate innovations does not yield considerable payoffs, revealing innovations may cut down market competition from immediate followers, and accelerate the product-to-market process (De Fraja, 1993).

Revealing contributes to the creation of industry standards (Harhoff et al., 2003; Lhuillery, 2006; Pénin, 2007). Standardisation may be a direct outcome or occur as a by-product of complementary firms adapting revealed knowledge to develop complementary products. A study conducted on IBM revealed that their decision to free-reveal knowledge of copper inter-connections in semiconductors to replace aluminium ones was driven by the expectation of making the copper technology an industry standard (Harhoff et al., 2003; Lim, 2009). By openly revealing their innovation, the manufacturers of semiconductor equipment managed to

implement the copper-interconnect semiconductors in the intended manner, thus delivering this improvement in semiconductor performance to a larger market.

Firms, especially in the OSS community, reveal to reciprocate others' contributions (Harhoff et al., 2003). Reciprocation is one of the founding principles of the open source concept (Raymond, 1999). Innovators in the open source community reveal to maintain reciprocity (Harhoff et al., 2003; Lakhani & von Hippel, 2003). Even if other players choose not to reciprocate, the reuse of revealed knowledge provides validation and reputation for the revealer. Furthermore, in the OSS industry in particular, developers contribute because they are passionate believers in open source and derive great satisfaction from belonging to the community (Lakhani & Wolf, 2003). Having an organisational culture that fosters such altruistic behaviour influences developers to contribute more to the open source community (Raymond, 1999). The possibility of accelerating the diffusion process also incentivises revealing (Harhoff et al., 2003). These motivations for practising revealing lead to a number of other benefits, such as network effects and innovation revealing becoming an informal standard (von Hippel, 2005a).

Most benefits of revealing are attached to the potentiality of the knowledge being reused and revealing efforts being reciprocated. The findings of the survey conducted by Henkel et al. (2014) confirm that revealing is the norm for firms operating within open source boundaries, indicating cooperation, reciprocation, possession of quality products as well as a sense of inclusion in the community. However, the requirement to reciprocate and reuse applies in other industries as well. For example, Tesla declared their patents as open source with the expectation the automobile industry would use and modify the knowledge, and then reciprocate to support efforts toward developing electric cars, thus creating an ecosystem that sustains the industry (Karamitsios, 2013; Ohnsman, 2014).

Revealing can promote improvements in manufacture when users provide feedback on revealed knowledge (Harhoff, 1996; von Hippel, 2005a). In an example cited by von Hippel (2005a), Technicon revealed their basic design for the first automated clinical chemistry analyser, which was then improved by the users (laboratory technicians), who in turn revealed these improvements via publications and through seminars and so on. Subsequent modifications to the design were carried out by employees of Technicon working with scientists in publicly-funded institutions. The subsequent innovations were then freely revealed, and the improvements to the analyser implemented by Technicon (Harhoff et al., 2003; von Hippel, 2005a). The innovators received reputation-related benefits. While this innovation was user

created (firms as users) and a result of operational activity rather than R&D outputs, revealing such knowledge still led to considerable improvements in the innovation landscape of clinical chemistry analysers, which was in return useful for supporting innovation in the user firms.

Most outcomes of revealing cannot be measured or evaluated using simple metrics as they are either indirect, delayed or intangible in nature. Therefore, firms' revealing choices are driven by the possibility of achieving beneficial outcomes.

2.3.1.2 Firm characteristics

Apart from the specific requirements of firms that drive revealing, cultural and structural firm characteristics, as well as their business models not only drive how firms reveal, but even the decision to reveal or not (Gassmann et al., 2010; Van Der Meer, 2007; von Hippel & von Krogh, 2006). In fact, studies have pointed out the challenges to implementing OI and related practices due to intra-firm resistance (Burcharth et al., 2014).

Openness in a firm depends on the 'mindset' (Gassmann et al., 2010). A culture and firm structures that embrace and enable collective development, externally sourced know-how and sharing are crucial to implementing OI practices, as amply demonstrated by previous studies reported in the OSS literature. Some innovative firms are built on the principle of free sharing and therefore value free sharing of knowledge (Harhoff et al., 2003; von Hippel, 2005a). There is abundant anecdotal evidence (examples in NZ: Silverstripe, Enspiral, Catalyst, etc.) about firms that are fundamentally geared toward sharing knowledge openly – it is in their 'DNA' (see Chan, 2013). However, as a result of the adaptation of OSS principles in non-software industries (Raasch et al., 2009) culturally driven revealing can be observed in other firms. In such instances the firms still may reveal for a specific purpose, but the drive to reveal is embedded in the organisation (Lakhani & Wolf, 2003).

There is research showing that the adoption of a 'private-collective' innovation model is influential in implementing comparatively seamless OI practices, especially revealing (Gassmann et al., 2010; Harhoff & Lakhani, 2016; Piller & West, 2014; von Hippel & von Krogh, 2003, 2006). In a private-collective model, as opposed to the private investment or collective action models (Olson, 1965; Ostrom et al., 1999), firms enjoy both private returns and collective action benefits. The model instrumentalises separation and management of private and the public good (von Hippel & von Krogh, 2006) in innovations. Revealing is not restricted to creating public good, as by following the principles for separation laid out in the model, managing the revealing process is made much easier. Once again, OSS is an example

of the application of private-collective model (Alexy & Reitzig, 2013; Gächter et al., 2010; von Hippel & von Krogh, 2003, 2006). OSS projects make the source code modules public good, while commercialising the compiled software. Other applications of 'private-collective' model can be found in creative industries (e.g. Erickson, 2018; Jeppesen & Frederiksen, 2006)

2.3.1.3 External pressures to reveal

Revealing can also be driven by factors external to the firm, such as competitive environments (Alexy et al., 2013) or industry characteristics (Henkel et al., 2014). Even though external factors may not be the sole driver of revealing, the research shows they provide strong motivations for firms to engage in the practice.

In highly competitive markets, the threat of substitution is a trigger for firms to reveal (Alexy et al., 2013). When firms attempt to protect innovations to avoid imitation, there is a potential for rival firms to innovate substitutions instead (Polidoro Jr. & Toh, 2011). Revealing thwarts substitution by disclosing all or parts of the innovation (Alexy et al., 2013). For example, when multiple players compete to develop solutions to the same problem, a firm revealing their solutions may trigger some externals (suppliers, complementary product manufacturers, users) to favour their innovation, thus creating a straightforward race which gives the revealing firm competitive advantage over others (Shapiro & Varian, 1999). Furthermore, in fast moving markets, firms reveal as a defensive strategy to prevent knowledge being appropriated by rivals (e.g. see Johnson, 2014). In industries where the technology is either too complex or not sufficiently complex for patenting, firms reveal innovations via other means that may not grant exclusive rights (Lhuillery, 2006) – e.g. scientific publications. The aim is to claim rights to the knowledge before rivals do by declaring ownership via revealing.

Operating in an industry where the norm is to reveal knowledge will require some firms to engage in revealing. For example, in an industry where revealing is considered an indication of value, business philosophy or quality of innovation, firms are forced to reveal at least some portion of knowledge to gain the credibility to operate within the market. Firms operating in such industries may be obligated to reveal as an act of reciprocation for using knowledge revealed by others in their internal innovations (de Jong & Flowers, 2018). An empirical study by Henkel et al. (2014) reported participants' claim that they did not need the 'bad publicity' as a reason for taking part in the open source movement (2014, p. 883).

Table 2-9 summarises claims made in the literature that explain why firms reveal. However, the extant studies do not delineate how these drivers are related, if at all, to the implementation

of revealing; especially when the revealing implementation could take different forms as shown by the four behaviours.

Table 2-9: Drivers of revealing

Drivers	Relevant items	
Potential outcomes	Avoid research duplication	(Alexy et al., 2013; Allen, 1983; Boudreau & Lakhani, 2015; Contreras, 2011; De Fraja, 1993; Grossman & Shapiro, 1986; Harhoff et al., 2003; Henkel et al., 2014; Lerner & Tirole, 2002; Nuvolari, 2004; Pénin, 2007; von Hippel, 2005a, 2005b; von Hippel & von Krogh, 2003)
	Reputation gains	
	Reciprocating others' efforts	
	Eliminate costs of secrecy	
	Accelerated diffusion and adoption of innovations	
	Standardisation and compatibility with complementary products	
	Induce manufacturer improvements	
Firm characteristics	Open culture	(Alexy & Reitzig, 2013; Gassmann et al., 2010; Harhoff et al., 2003; Van Der Meer, 2007; von Hippel & von Krogh, 2003, 2006)
	'Private-collective' style of innovation model	
External pressures	Operating in competitive markets	(Alexy et al., 2013; de Jong & Flowers, 2018; Henkel et al., 2014)
	Industry norms	

As previously discussed, the four behaviours show how firms may strategically engage in revealing that considers the risks and vulnerabilities of openness. Therefore, understanding what motivates firms to adopt the behaviours is of utmost importance to gaining theoretical and practical insights into how firms implement revealing.

2.4 Revealing capabilities

The literature on revealing mechanisms and open innovation indicates that firm capabilities are important when managing knowledge resources especially for outbound OI (e.g. Lichtenthaler & Lichtenthaler, 2009; Simeth & Lhuillery, 2015). However, the conversation in the existing literature on capabilities to reveal knowledge is weak. This study, therefore, builds on theoretical perspectives relevant to firm capabilities required to manage and share knowledge resources (Cheng et al., 2016; Eisenhardt & Martin, 2000). Table 2-10 presents the five capabilities identified through several scholarly conversations relevant to this thesis.

Revealing discloses 'knowledge' which are outputs of the internal innovation process of a firm (Chesbrough, 2003a). Therefore, a prerequisite to identifying revealing capabilities is to clarify what constitutes 'knowledge' in a firm from a revealing perspective.

Table 2-10: Capabilities for revealing explained

Capabilities	Description	
Modularity	Ability to breakdown the knowledge into manageable modules. Modules can include: decisions, tasks, or components that are partitioned into subsets.	(Baldwin & Clark, 2000; Baldwin & Henkel, 2012; Schilling, 2000; von Hippel & von Krogh, 2006)
Decontextualising and codification	Simplifying and generalising knowledge sufficiently for a general audience to understand. Codification includes simplified, technical or creative presentation skills	(Cheng et al., 2016; Schulz, 2001; Simeth & Lhuillery, 2015)
Absorptive capacity	Internalising externally obtained knowledge. Capacity to recontextualise knowledge received and apply it internally.	(Alexy et al., 2013; Cohen & Levinthal, 1990; Lichtenthaler & Lichtenthaler, 2009; Lim, 2009)
Desorptive capacity	Applying internal knowledge in external contexts to create advantage. Includes identifying opportunities and applying the knowledge.	(Chesbrough, 2006; Lichtenthaler & Lichtenthaler, 2009)
Timing of revealing	Final or intermediate revealing within the innovation process	(Boudreau & Lakhani, 2013, 2015; Pacheco-de-Almeida & Zemsky, 2012)

2.4.1 Defining knowledge for revealing

Knowledge of the firm consists of tacit and explicit parts which interact to perform specific actions (Hadjimichael & Tsoukas, 2019; Nonaka, 1994; Polanyi, 1966) – also known as the 'possessed' knowledge (Cook & Brown, 1999). Tacit refers to the 'know-how' such as skills and expertise, and the explicit refers to the 'know-what' such as information and facts (Kogut & Zander, 1992; Lichtenthaler & Lichtenthaler, 2009). Explicit knowledge can be formalised through systematic codification using metaphors, symbolic representations or analogies (Cowan et al., 2000; Nonaka & Takeuchi, 1995). It is easily communicable and transferable between firms or individuals (Hall & Andriani, 2002). Explicit knowledge can be identified via the formalised IP of the firm such as patents and published papers; or informalized as copyrighted material such as protocol manuals, captured in knowledge management systems; or presented verbally by individuals.

Tacit knowledge, however, is harder to articulate and is embedded in organisational routines as well as individuals (R. R. Nelson & Winter, 2004; Polanyi, 1966) but is necessary to apply the explicit knowledge when performing actions. Tacit knowledge in firms can exist in relationships, expertise and skills embodied in individuals or collectively held in groups (Cook & Brown, 1999; Hadjimichael & Tsoukas, 2019; Lam, 2000). The only way to transfer tacit knowledge is through shared experiences, close interactions, participation or observations (Hall & Andriani, 2002; Ribeiro & Collins, 2007).

Application of knowledge when performing actions is complemented by 'knowing' – the knowledge embedded in actions (Cook & Brown, 1999). Practice-embedded knowing enables the application of possessed knowledge (Cook & Brown, 1999) – also known as know-how-in-action (Hadjimichael & Tsoukas, 2019). Knowing exists only when actions are performed and uses tacit knowledge as a tool.

Knowledge within a firm is a combination of knowledge and knowing that is held by individuals (employees)/groups as well as knowledge embedded in firm's methods and systems (Cook & Brown, 1999; Hadjimichael & Tsoukas, 2019). Knowledge and knowing of individuals/groups within the firms is bounded by the culture, systems and norms of the firm (Hadjimichael & Tsoukas, 2019). Therefore at the firm level, the knowledge that is of value to the firm can be considered a cumulation of both firm's systematic knowledge and the knowledge and knowing that exist in its employees.

Both possessed and practice-embedded knowing are relevant for revealing. Outputs of innovation activities are suggestive of regenerating knowledge and knowing which helps create unique value to the firm (Cook & Brown, 1999). Hence the 'knowledge' that firms reveal consists of innovation outputs that include both possessed knowledge –explicit and tacit– and practice-embedded knowing. Even though most reported studies on knowledge outflows largely ignore providing an explicit definition for the term, methods used for outflows indicate that firms reveal explicit and tacit knowledge. For example, Selective- and free-revealing studies discuss explicit knowledge outflows through channels such as sharing OSS source codes, scientific and informal publications, and patents (Alexy et al., 2013; Henkel et al., 2014; Schweisfurth et al., 2011). Studies on disclosure and spillovers, discuss methods of sharing both explicit and tacit knowledge such as virtual, printed or other encoded material, hands-on workshops, hosting external personnel such as interns, personnel exchange between firms, and site visits (Lhuillery, 2006; Pénin, 2007); the methods that call for personal interaction provide opportunities for shared experiences, observation and learning that transfer tacit knowledge as well as explicit knowledge. When personal interactions take place in close quarters, sharing practice-embedded knowing is inevitable. Furthermore, studies show that knowing is shared and reinvented through 'communities of practice' (see Laursen and Salter 2006). This indicates that knowing can be shared through interaction as the same as tacit knowledge, even though they may only be understood and reapplied by the respective practice groups e.g. knowing relevant to mechanical engineering is only understood by mechanical engineers (see Brown and Duguid 1991, 1998).

Demarcating the differences between knowing and tacit knowledge, particularly the empirical identification of both, requires an epistemological discussion that is beyond the scope of this thesis (see Cook & Brown, 1999; Hadjimichael & Tsoukas, 2019). This study, therefore, focuses on the revealing of unique explicit (encoded facts and information – e.g. IP, process/protocol manuals) and tacit knowledge resources (routines and expertise – e.g. firm-specific processes of manufacturing) that are outputs of an innovation process and are possessed by the firm and members within the unit. However, this study acknowledges that knowing is revealed by firms and is inevitably included in the empirical observations even though a clear demarcation is not made at this stage.

Revealing internal knowledge – both explicit and tacit – is risky for firms (Frishammar et al., 2015; Ritala et al., 2018). Revealing internal resources is a decision based on trade-offs between the returns from appropriation and the non-pecuniary benefits (Alexy et al., 2013). The knowledge the firms reveal is created internally through the innovation process (Chesbrough, 2003a; West et al., 2014). Such innovative knowledge outputs are unique and valuable to the firm (J. Barney, 1991; King & Zeithaml, 2003). Revealing such knowledge, therefore, could affect the competitive advantage of the firm (Polidoro Jr. & Toh, 2011) if 'too much' knowledge or business-critical knowledge is revealed (Frishammar et al., 2015; Ritala et al., 2018). Furthermore, the intention of revealing is to achieve non-monetary benefits which are, by design, unmeasurable (Alexy, 2009; Dahlander & Gann, 2010; Harhoff et al., 2003). Therefore, firms need to ensure that the knowledge they reveal is appropriate, sufficient and valuable enough to achieve the intended outcomes. Prior studies show that firms require specific routines and tasks to ensure that firm knowledge is prepared for revealing (e.g. Lichtenthaler and Lichtenthaler 2009; Simeth and Lhuillery 2015). The capacity to establish such routines and tasks to manage knowledge resources for OI related activities are found in firm capabilities (e.g. Cheng et al., 2016; Lichtenthaler & Lichtenthaler, 2009; Simeth & Lhuillery, 2015).

2.4.2 Capabilities to implement revealing

Dynamic capabilities (DC) (Eisenhardt & Martin, 2000; D. Teece & Pisano, 1994) is suited to provide insights to understand the firm capabilities relevant to revealing. DC is an extension of the resource based view (RBV) of the firm (J. Barney, 1991; Wernerfelt, 1984, 1995). RBV theorises that firm's physical, human and organisational capital forms the resources required to improve the efficiency and effectiveness of its value creation strategies (J. Barney, 1991). To create competitive advantage firm resource need to be valuable, rare, inimitable, and non-

substitutable (VRIN) (Alexy et al., 2018; Halawi et al., 2005). This view has received criticism for being tautological and is questioned for its applicability in sustained competitive advantage (Kraaijenbrink, Spender, and Groen 2010; Priem and Butler 2001b, 2001a). Instead, the resources of the firm are to be viewed as a 'bundle' that can be integrated and reconfigured to gain competitive advantage (see Kraaijenbrink, Spender, and Groen 2010).

DC, extending the perspectives of RBV, emphasise the importance of capabilities in developing competitive advantage of the firm when competing in unpredictable, ever-changing markets (Barreto, 2010; Prieto & Easterby-Smith, 2006; D. Teece & Pisano, 1994). Firms develop leverage by combining and integrating resources in a unique firm-specific way when competing with competitive markets (Peris-Ortiz et al., 2018). Capabilities refer to this capacity of the firm to integrate, reconfigure, obtain or release resources using organisational routines and processes to satisfy a specific objective (Amit & Schoemaker, 1993; Eisenhardt & Martin, 2000). Capabilities alter the resource base to develop value creating strategies that subsequently generate new sources of competitive advantage (Eisenhardt & Martin, 2000; D. Teece, 1986). They become 'dynamic' when there is potential for the capabilities to change and adjust based on the changing external environments to sustain the competitive advantage (Barreto, 2010; Prieto & Easterby-Smith, 2006; D. Teece & Pisano, 1994; Winter, 2003). Even though the dynamic nature of the capabilities are beyond the focus of this study, the theoretical perspectives on firm capabilities presented in DC, especially relevant to the knowledge-based resources, are relevant to understand and identify firms' revealing capabilities.

Knowledge is a strategic resource of the firm (Conner & Prahalad, 1996). Revealing purposively allows firms to 'transfer' the knowledge resources to external parties. Therefore, based on the perspectives of DC, Capabilities are important for revealing for two reasons. One, they ensure that firm's core competencies are enhanced when they embrace revealing activities (Alexy et al., 2018; Cheng et al., 2016) and new competencies are developed (Cheng et al., 2016; Eisenhardt & Martin, 2000). The competitive advantage largely depends on firm resources being protected (controlled through ownership) and appropriated by the firm (J. Barney, 1991). Revealing seemingly go against these notions and purposively make knowledge accessible to external parties (Alexy et al., 2018). Even though all revealing activities do not relinquish ownership to the knowledge, control over the knowledge once revealed is lost which may encourage imitability, reconfiguration and substitution, e.g. open sourced patents provide necessary explicit knowledge to recreate and improve the technology or product. On the contrary, revealing complements the firm's competitive advantage with its non-monetary

benefits (Alexy et al., 2018). Benefits such as gaining access to new resources and capabilities, partnering with rivals to innovate, and cost and risk sharing, complements the firm's already existing resources to create new configurations of resource bundle (Cheng & Huizingh, 2014; Ritala et al., 2018; Sarkar, 2017a). Therefore, capabilities are important to identify complementary resources and capabilities that can enhance the current resource bundle (Cheng et al., 2016). Furthermore, a firm's decision to reveal internal knowledge doesn't mean it seizes to be competitive or profit-oriented (see Alexy et al., 2018). Therefore, routines and processes that sense opportunities and threats in the external environment are important to identify the knowledge resources that are of value to seize the opportunities (D. J. Teece, 2007). Such capabilities ensure that only the most relevant knowledge is revealed, and the selected knowledge is appropriated and timely revealed to achieve the potential benefits.

Two, capabilities are important to prepare the knowledge for revealing. Knowledge is a strategic resource of the firm (Spender & Grant, 1996) and is believed to lose value if exposed too widely (Frishammar et al., 2015; Li et al., 2008; Ritala et al., 2018). Therefore, firms require routines and processes to ensure that only the required knowledge is revealed. knowledge, as discussed before, is a combination of tacit and explicit parts. Explicit knowledge is bounded, scoped and well-articulated thus allowing the transfer of them much easier. However, the knowledge that is not codified, even if they could be, and is not well understood is harder to be evaluated (Argote et al., 2003). Furthermore, some revealing behaviours identified in this study require firms to have processes to filter knowledge for selectivity (e.g. Alexy et al., 2013; Henkel et al., 2014). Selectivity is required due to the high proprietary values, high imitability that adversely affect the revealing firm, or simply to identify the specific knowledge of value to the purpose. To meet such requirements revealing capabilities require to act as 'intermediate transformation abilities' of the firms that convert knowledge resources into the desired goal (Dutta et al., 2005). In revealing, the goal is to prepare knowledge resources appropriately to address the aforesaid requirements. For this, firms require capabilities that establish routines to reconfigure knowledge resources, enable making strategic decisions on how, when and what to reveal and define shareable knowledge (Eisenhardt & Martin, 2000). These routines prepare firm knowledge to be revealed strategically without compromising the competitive advantage of the firm.

Among the firm capabilities pointed out in the literature, this study identified five capabilities that could address the two requirements relevant to revealing outlined above. They are: modularising to make the knowledge components manageable (Alexy et al., 2013; Baldwin &

von Hippel, 2011; Henkel & Baldwin, 2009), de-contextualising and codification (Simeth & Lhuillery, 2015), absorptive capacity to internalise the resultant knowledge inputs (Alexy et al., 2013; Lichtenthaler & Lichtenthaler, 2009), desorptive capacity to find opportunities and apply knowledge externally (Chesbrough, 2006; Lichtenthaler & Lichtenthaler, 2009), and timing of revealing (Boudreau & Lakhani, 2015). These capabilities are discussed in detail in the following paragraphs.

The capacity to modularise is an important capability in any revealing firm. Firms should not reveal knowledge that is of no value as the potential for re-use of the same will be minimal (Polidoro Jr. & Toh, 2011). On the other hand, revealing knowledge of high value is risky, but can bring high return to the firm (D. Teece, 1986) through increased reuse. Therefore, being able to strategically reveal knowledge modules is an advantage for the revealing firm. Modules are units of a larger system or architecture that are structurally independent but work together (Baldwin & Clark, 2000, p. 63). Hence modularity is created when a system is divided into modules that have tight inner links, but are loosely linked to other parts of the system (Baldwin & Clark, 2000; Henkel & Baldwin, 2009; Schilling, 2000). All modules need to work in unison for the entire system to work. If the resource base of a firm is modular, it is easier to select knowledge modules to reveal without damaging IP in the form of the developed software for example, which remains proprietary (Alexy et al., 2013; Baldwin & Henkel, 2012). This practice is prominent in open source software industry, where the source codes are revealed while the compiled software can be licensed (von Hippel & von Krogh, 2006). Furthermore, modularity enables firms to be selective in terms of what knowledge modules to reveal without affecting the other modules, or the value of combined architecture (Henkel & Baldwin, 2009). Modularity is essential in collaborations to prevent intense ‘across module’ communication and ensure unnecessary knowledge leakage does not occur. Selective access can be provided only to the appropriate knowledge modules. This selectivity is not only useful in revealing, but also in defining the boundaries of the collaborative outputs (Baldwin & von Hippel, 2011) – e.g. who owns which IP.

In revealing, knowledge needs to be decontextualised to make it relatable to a wider audience before revealing, but at the same time needs to be sufficiently complex and contextual to maintain compatibility with the revealing firm (Alexy et al., 2013). Firms need unique expertise to translate knowledge in such a manner (Simeth & Lhuillery, 2015). Scientific publishing requires the writing skills to express the knowledge in a comprehensive, simple yet rigorous manner. Even journalists and bloggers are challenged in terms of the skills required to write

for a lay audience. Further, preparing patents requires the legal and technical skills to present the knowledge while creating the case for the knowledge as a legal entity, as well as maintaining the accuracy of technical aspects. Therefore, possessing the necessary capabilities to transform the knowledge is an essential factor for revealing firms (for examples relevant to scientific publications, see Gittelman & Kogut, 2003; Kinney, Krebbers, & Vollmer, 2004).

Several studies provide insights into the role of capabilities in OI implementation in general (e.g. Cheng et al., 2016; Grimaldi, Quinto, & Rippa, 2013; Lichtenthaler & Lichtenthaler, 2009), however none specify the capabilities explicitly relevant to revealing activity or its implementation process. Knowledge sharing capabilities (Cheng et al., 2016) and absorptive and desorptive capacities (Lichtenthaler & Lichtenthaler, 2009) are close exceptions. However, due to the perspective on OI adapted by the authors (OI as a singular model), the specific applicability of these capabilities in the revealing context is unclear.

Knowledge sharing capabilities enable effective sharing of internal knowledge with externals (Cheng et al., 2016). These capabilities consist of specific routines and processes that streamline the sharing of internal knowledge resources (Schulz, 2001). The routines are relevant to collecting, codifying and combining knowledge resources. Parallels to these routines can be drawn from the above discussion on decontextualisation and codification (Simeth & Lhuillery, 2015). Both capabilities refer to the firm's capacity to effectively modify and arrange the internal knowledge for external sharing in general, as well as wider contexts. However, knowledge sharing capability encompasses a broader range of knowledge dynamics relevant to both internal and external knowledge sharing. Therefore, in this study context, decontextualisation and codification are considered more relevant.

Absorptive and desorptive capacities are required in relation to inbound and outbound knowledge resources (Lichtenthaler & Lichtenthaler, 2009). Possessing sufficient absorptive capacity to re-contextualise and internalise the resultant knowledge creation of a revealing effort is a challenging but crucial capability for revealing (Alexy et al., 2013), especially in circumstances where the firm expects to induce new knowledge creation via revealing (e.g. collaborations). Absorptive capacity focuses on internalising externally sourced knowledge (Cohen & Levinthal, 1990; Lim, 2009). Desorptive capacity, on the other hand, is the capability to exploit internal knowledge externally; that is, the routines for identifying opportunities external to the firm and applying internal knowledge in the external context (Chesbrough, 2006; Lichtenthaler & Lichtenthaler, 2009). Identifying viable external opportunities to invest effort in exploiting is a key challenge for firms, even with financial incentives. In the absence

of monetary incentives, it is even more challenging and requires prior knowledge and experience for success (Lichtenthaler & Lichtenthaler, 2009). Even though presented more as a capability for 'selling', desorptive capacity aids revealing firms to identify opportunities where intangible benefits can be gained through transferring internal knowledge, for example IBM's knowledge transfer efforts for semiconductor technology for potential standardisation of the technology. However, the current conversation in revealing still lacks insights into these specific capabilities that enable the managing, and implementation of the revealing (cf. Randhawa et al., 2016).

Timing of revealing activities within the innovation process helps in strategising revealing (Boudreau & Lakhani, 2013, 2015). Various scholars have sought to identify how OI is strategically implemented in firms (e.g. Cheng & Huizingh, 2014), including investigations of specific activities that firms implement to strategise the OI process. No similar effort has been invested in revealing. However, studies by Boudreau and Lakhani indicate that disclosure policy defines the timing of revealing (2013, 2015). The timing of activities in innovation is crucial in R&D to secure market share, gain lead-time advantage and even to the search and transfer of new technologies (Pacheco-de-Almeida & Zemsky, 2012). In line with this reasoning, the timing of revealing can also be considered a critical choice that firms need to make to gain incentives or induce reusability.

Table 2-11: Disclosure policies in revealing

Disclosure policy	Description	
Final disclosure	Patents, scientific publications, app releases, working solutions to problems	(Baldwin & Clark, 2000; Chesbrough, 2003a; Cohen et al., 2000; Hicks, 1995; Stephan, 1996)
Intermediate disclosure	Source code contributions (Open source) bug/improvement reports, idea submissions	(Allen, 1983; Lakhani & von Hippel, 2003; Lakhani & Wolf, 2003; Lerner & Tirole, 2002; Nuvolari, 2004)

In what has been termed 'disclosure policy' (table 2-11), firms define when the revealing should occur in the innovation process, depending on the requirements of the firm. In a 'final disclosure' policy, firms develop innovations internally and reveal the final knowledge outputs, which are standardised and integrated in some form. 'Intermediate disclosures', on the other hand, are ongoing throughout the innovation process and are not necessarily tested and finalised knowledge (Boudreau & Lakhani, 2013, 2015). Examples of intermediate disclosures can be found in the open source software context where source code is revealed for bug testing

by external users, and also in non-software settings such as the 'collective invention' ventures of the early 20th century (See Allen, 1983; Nuvolari, 2004) as well as aviation technology (Meyer, 2013).

Timing of revealing further defines the 'form' of the knowledge at the revealing point. Final disclosures typically involve vetted, validated, and somewhat standardised knowledge. Intermediate disclosure, on the other hand can involve varying magnitude in terms of the knowledge components revealed. Such knowledge may be unverified, work-in-progress outputs (Boudreau & Lakhani, 2015).

Defining their disclosure policy largely depends on the type of outcome firms expect. Intermediate disclosure leads to higher chance of reuse and faster development of knowledge. It further ensures that the revealed knowledge cannot be appropriated by upstream innovators and users. Scientific and academic publications generally facilitate intermediate revealing, allowing the community to reuse and built on the knowledge (e.g. Hicks, 1995; Polidoro Jr. & Theeke, 2009). Final disclosure derives more incentives to the firm and usually involves disclosure in the form of patents (Nuvolari & Sumner, 2013). The revealing firms can then reap the benefits of their ownership of the knowledge, while allowing the knowledge to be used in non-commercial ventures.

It is unclear, however, if and how timing affects revealing behaviours. Because there are indications suggesting behaviours are linked with the mechanisms of revealing, it is logical to argue that timing of revealing determines, at the least, the selectivity of access to the revealed knowledge. Furthermore, timing can be linked with the firm's capacity to modularise the knowledge. OSS represents an exemplary mechanism demonstrating both intermediate and final disclosure, and links timing with these capabilities. However, the extant literature does not provide conclusive evidence to confirm these links.

2.5 The research gaps

Gaps in the existing scholarly work highlights that understandings of revealing implementation remain underexplored. The review provides an understanding on the prevailing conversation of revealing in OI and related theoretical fields.

The review shows that there are different types of revealing that, when systematically organised, present four revealing behaviours. The four revealing behaviours indicate that firms can implement revealing by changing the amount of content revealed and the access provided

to the revealed knowledge. While the mechanisms are the observable indicators of revealing, the revealing behaviours cannot be identified through examining the mechanisms alone.

The review further shows that drivers for revealing and firm capabilities influence the revealing activities in firms. Expectations of the potential outcomes, firm characteristics and external pressures drive firms to reveal. Firm capabilities relevant to managing the knowledge resources facilitate revealing activities.

However, the current scholarly work does not provide any insights to elucidate why there is a variation in revealing implementation and how the firm-level factors, if they do at all, relate to the revealing behaviours. These gaps pose several sub questions in pursuit of addressing the main research question.

Table 2-12 summarises the research question (RQ), the findings from the review and the emerging sub questions that helps to address the main RQ of the study.

Table 2-12: Summary of review findings and research gaps

RQ/s	From literature review	Emerging sub questions to address the main RQ
Why and how do firms implement revealing?	***Revealing behaviours:*** Varies based on the *access* to knowledge and the amount of *content* revealed *Four behaviours* - Extreme, content-controlled, access-controlled and restrictive	What firm-level factors influence the firm's revealing behaviour/s? & Why? How do firm-level factors relate to the implementation of revealing behaviour/s?
	Mechanisms of revealing: OS contributions; scientific publications; patents; collaborative innovation	
	Drivers to reveal: Potential outcomes; firm characteristics; external pressures	
	Capabilities for revealing: Modularity; de-contextualising; codification; absorptive capacity; Timing policy *From OI*: desorptive capacity; knowledge sharing capabilities	
Contributing articles: (Alexy et al., 2013; Boudreau & Lakhani, 2015; Cheng et al., 2016; Gassmann et al., 2010; Harhoff et al., 2003; Harhoff & Lakhani, 2016; Henkel, 2006; Henkel et al., 2014; Henkel & Baldwin, 2009; Lichtenthaler & Lichtenthaler, 2009; Muller & Pénin, 2006; Pénin, 2005, 2007; Simeth & Lhuillery, 2015; Van Der Meer, 2007; von Hippel, 2005a)		

The empirical phase of the study focuses on examining revealing behaviours and exploring the firm level factors associated with the revealing behaviours to draw insights on how firms implement revealing. The empirical work toward answering the research questions is guided by a conceptual framework, which draws directly on the literature referencing the behaviours, drivers, capabilities, timing and mechanisms of revealing. The following section elaborates on the conceptual framework that will guide the empirical work of this study.

2.6 Conceptual framework development

Key aspects identified in the preceding sections combine to form the conceptual framework for this study. The conceptual framework guides the research design used to address the research questions. It presents a meticulous arrangement of ideas about the phenomenon under scrutiny (Miles et al., 2014). As described by Maxwell (2012), the conceptual framework is a formulation of what the researcher think is going on – a tentative theory of the phenomena under investigation (Maxwell, 2013). A conceptual framework is often viewed as an oversimplification of the complex reality that corresponds with the interpretivist perspective (Maxwell, 2013). Therefore, it serves the purpose of offering guidance to the study by providing insights and broadening the understanding of a phenomenon.

The conceptual framework should be consistent with the research design for a study (Miles et al., 2014; Myers, 2013). It is a graphical or narrative presentation of the "main things to be studied" (Miles et al., 2014, p. 20), such as the key factors, constructs or variables, and presumed relationships (Maxwell, 2013; Miles & Huberman, 1994). The conceptual framework for this study was constructed based on the findings from the literature of several fields, as presented earlier in Chapter 2 (Maxwell, 2012).

The framework for this study conceptualises the linkage between revealing behaviours and related firm factors to answer the overarching research question:

Why and how do firms implement revealing?

To recap from the literature, firms can exhibit four revealing behaviours depending on restrictions to access or the amount of knowledge revealed. The study assumes that one firm may exhibit one or more of these behaviours.

The observable aspect of revealing is the revealing mechanisms used. However, mechanisms are not indicators for revealing behaviours. While the access control aspects of the mechanisms are clear, knowledge selectivity is not. Therefore, due to complexities in drawing the boundaries around knowledge, mechanisms cannot be directly linked with a specific behaviour.

Firm-level factors, namely drivers and capabilities, affect overall revealing. Drivers determine if firms want to reveal at all. The review showed that potential outcomes, firm characteristics and external pressures drive revealing activities. Capabilities support (or limit) management of the implementation of revealing activities. The review identifies five capabilities relevant to the revealing activities – modularity, decontextualising and codification, absorptive and desorptive capacities and timing of revealing. The empirical phase of the study aims to explore these factors further and identify the links between the firm-level factors and revealing behaviours to address the research question.

2.6.1 The framework constructs

Based on the literature, the following factors contribute to the formation of the conceptual model.

1. Firms exhibit four behaviours of revealing, varying based on two dimensions (Fig. 2-2);
2. Firms use four key mechanisms to practice revealing (Table 2-8);
3. Two antecedent factors are associated with revealing (Table 2-10)

Figure 2-6 illustrates the conceptual model for the study. An outline of the conceptual framework follows, which provides the details the framework items.

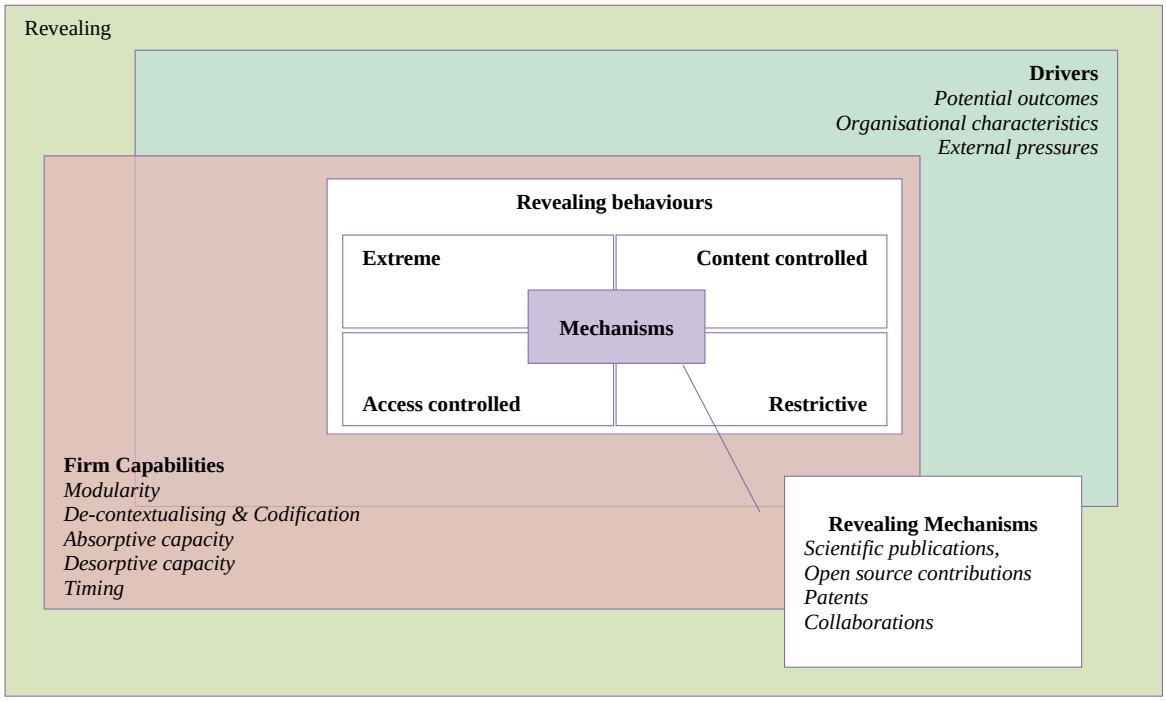

Figure 2-6: Conceptual framework

The framework proposes that within the boundaries of a firm, revealing is a result of the interplay between drivers and capabilities. Revealing can exist as one of the four behaviours,

or various combinations of the four. Implementation of the behaviours is displayed through the mechanisms, which are the observable output.

Literature was reviewed repeatedly to identify relevant constructs that would provide a neither too restrictive nor too generous perspective on the issue at hand (Miles et al., 2014). In the process, it was necessary to discard seemingly valuable constructs, after weighing them off against the ones that were eventually selected. The inclusion criteria for the constructs were their appearance in articles that contributed to the field and were published in journals held in high regard, and which had been cited more often, for example Alexy et al., (2013), Harhoff et al., (2003), and Henkel et al., (2014). The operationalisation of the framework constructs is presented below.

2.6.1.1 Revealing behaviours and mechanisms

Four revealing behaviours are derived from the literature.

Table 2-13: Revealing behaviours explained

Behaviours	Description
Extreme revealing	No selectivity in knowledge revealed No restrictions in access allowed Open to all; public good creation *Mechanisms:* Open source contributions, scientific publications, patents
Content-controlled revealing	Selectivity in knowledge observed. No restrictions in access allowed. Open to all; public good creation *Mechanisms:* Open source contributions, scientific publications, some open-collaborations
Access-controlled revealing	No selectivity in knowledge. Access is restricted to a chosen few (can be a single party or multiple parties) *Mechanisms:* Joint ventures, strategic alliances, user innovation activities, some collaborations
Restrictive revealing	Selectivity in knowledge observed. Access restricted to a chosen few. *Mechanisms:* Joint ventures, strategic alliances, user innovation activities, pre-collaborations discussions

They are presented as derivatives of restrictions along two dimensions – access to revealed knowledge and the amount of knowledge revealed (Alexy et al., 2013; Harhoff et al., 2003; Henkel, 2006; Henkel et al., 2014; Muller & Pénin, 2006; Pénin, 2005, 2007). Table 2-13 summarises the factors for each revealing behaviour. Four key mechanisms of revealing were identified from the literature (Table 2-6). Firms may use derivations or combinations of these mechanisms in their revealing practice.

2.6.1.2 Drivers of revealing

Combining several fields of literature, three factors are identified that drive revealing (Table 2.9) – potential outcomes, firm characteristics and external pressures (Alexy & Reitzig, 2013; de Jong & Flowers, 2018; Harhoff et al., 2003; Henkel et al., 2014; Muller & Pénin, 2006; Pénin, 2007; Van Der Meer, 2007; von Hippel, 2005a). Potential outcomes are a strong motivator for firms to engage in revealing activities. Outcomes can be either direct or indirect and are mostly intangible in nature. Therefore, firms' revealing choices are dependent on the possibility of beneficial outcomes. In this context, the firm characteristics identified here act as catalysts to drive revealing and support its implementation. Finally, external pressures force firms to reveal to sustain competitive advantage.

2.6.1.3 Capabilities for revealing

Revealing activities are bounded by firm capabilities, which refer to the firm's capacity to combine resources for a desired goal (Amit & Schoemaker, 1993; Barreto, 2010; Eisenhardt & Martin, 2000). These include organisational routines for integrating, reconfiguring, and releasing resources to create new configurations of resources (Amit & Schoemaker, 1993; Barreto, 2010; Eisenhardt & Martin, 2000; Kogut & Zander, 1992; Prieto & Easterby-Smith, 2006). For the purpose of this study, only the capabilities relevant to managing knowledge resources are considered.

The literature contextualising open source software (OSS) and open science indicates modularity along with decontextualising and codification as important capabilities for revealing (Alexy et al., 2013; Cheng et al., 2016; Henkel & Baldwin, 2009; Simeth & Lhuillery, 2015). Further, absorptive capacity and desorptive capacity were identified from the open innovation literature (Lichtenthaler & Lichtenthaler, 2009). Finally, timing determines when to reveal, i.e. the disclosure policy (Boudreau & Lakhani, 2015). Revealing that occurs at the end of an innovation process is 'final', while any continuous revealing efforts during the process are 'intermediate'. Timing defines the knowledge 'form'. Final disclosure reveals validated and finalised knowledge, while intermediate revealing includes untested, work-in-progress knowledge. Both can co-exist in the same project, as with open source software.

Table 2-10 summarises capabilities relevant to the conceptual framework. However, discussion of capabilities in the revealing literature is scarce. Therefore, the empirical phase of the study will seek to identify more capabilities through the process of data analysis.

2.7 Chapter summary

This chapter reviewed articles from multiple theoretical fields to inform the development of a conceptual framework to address the research question. Theoretical perspectives derived from industrial economics and resource based view, specifically the dynamic capabilities were integrated in developing a framework to guide the empirical study.

The framework scopes the study according to the identified concepts and forms the boundaries for performing the empirical study (Miles et al., 2014). In the absence of an established theory for revealing, the developed conceptual framework provides the guidance necessary to perform the research method. Table 2-14 presents a summary of the concepts underpinning the framework.

Table 2-14: Conceptual framework items

Concept	Items	Operational Descriptions
Revealing behaviours	Extreme revealing	No selectivity in knowledge revealed No restrictions in access allowed Open to all; public good creation *Mechanisms:* Open source contributions, scientific publications, patents
	Content-controlled revealing	Selectivity in knowledge observed. No restrictions in access allowed. Open to all; public good creation *Mechanisms:* Open source contributions, scientific publications, some open-collaborations
	Access-controlled revealing	No selectivity in knowledge. Access is restricted to a chosen few (could be a single party or multiple parties) *Mechanisms:* Joint ventures, strategic alliances, user innovation activities, some collaborations
	Restrictive revealing	Selectivity in knowledge observed. Access restricted to a chosen few. *Mechanisms:* Joint ventures, strategic alliances, user innovation activities, pre-collaborations discussions
Drivers of revealing	Potential outcomes	Avoid research duplication
		Reputation gains
		Reciprocating others' revealing efforts
		Eliminate costs of secrecy
		Accelerated diffusion and adoption of innovations
		Standardisation and compatibility with complementary products
		Induce manufacturer improvements
	Firm characteristics	Open culture
		'Private-collective' style of innovation model
	External pressures	Operating in competitive markets
		Industry norms
Capabilities	Modularity	Ability to breakdown the knowledge into manageable modules.

Concept	Items	Operational Descriptions
		Modules can include decisions, tasks, or components that are partitioned into subsets.
	Decontextualizing and codification	Simplifying and generalising knowledge sufficiently for a general audience to understand Codification includes simplified, technical or creative presentation skills
	Absorptive capacity	Internalising externally obtained knowledge.
	Desorptive capacity	Applying internal knowledge to gain advantage from external contexts
	Timing of revealing	Final or intermediate revealing within the innovation process

The conceptual framework is organic and therefore open to continuing development through literature and research findings. It will be subject to refinement as a result of the empirical outcomes (Miles et al., 2014). Along with the empirical methods used, the framework is essential to the gathering, analysis and presentation of data in the following chapters. The next chapter presents the methodology of choice, the data collection methods, and analytical procedures used to conduct the empirical work.

CHAPTER 3 RESEARCH DESIGN

The purpose of this chapter is to present and justify the methodological choices and the research design applied in the study. This includes the arguments for the methodological choice, the philosophical assumptions relevant to the chosen research approach, and details of the empirical study.

First the chapter explain and justify the choice of qualitative methodology chosen for the study. This explains the appropriateness of using a qualitative approach and presents the ontological and epistemological assumptions that are relevant to the study. Next, the chapter presents and justifies the multiple case study method, explains the sampling criteria, study context and provides an overview of the selected case firms. The sections that follows explain the data collection method outlining the data sources and collection procedures. Finally, the data analysis strategy is explained, followed by a summary of the research design concluding the chapter.

3.1 Research methodology

Methodologies in social sciences are broadly grouped as quantitative, qualitative and mixed methods (Creswell & Creswell, 2018; Edmondson & McManus, 2007). These methodologies are associated with specific ontological and epistemological foundations. Ontology relates to philosophical study of the nature of reality and its characteristics (Creswell & Creswell, 2018). It deals with issues concerning the existence of social entities and how they can be organised. The epistemology concerns the nature and scope of knowledge; addresses the questions of what constitutes knowledge and how is it created (Bryman & Bell, 2011).

Methodology of this study is a qualitative one, grounded in a subjective ontology with an interpretivist epistemological perspective. Subjectivism, advocates that actors within the social entity shape the entity and provides meaning (Bryman & Bell, 2011). Therefore, this study embraces the idea of multiple realities shaped by the actors and aims to report the multiple realities (Creswell, 2014). Interpretivism assumes that knowledge can be created and understood from the perspective of the actors who live and work in a social entity. It is important to conduct the study in the ‘field’, which provides the context to understand the perspectives of the participants (Creswell, 2014). A qualitative approach of this study is aimed at developing subjective meaning by looking for complexity of views rather than narrow the meanings into few categories or ideas (Creswell & Creswell, 2018; Denzin & Lincoln, 2011).

A qualitative approach is used for two reasons. First, a qualitative inquiry allows to refine and clarify constructs. The literature review (Chapter 2) suggested that revealing as a construct in OI required much theoretical and empirical fineness before moving forward developing measurable scales. The review shows that revealing is a combination, that is more than a summation, of the drivers, firm capabilities, as well as the revealing behaviours (varying characterisations of access and/or content) (see Law, Wong, & Mobley, 1998). Due to the lack of sufficient extant empirical and conceptual work around the topic makes it difficult to develop scales that capture the key variables and their inter-relations that forms revealing. In other words, the construct of revealing require much clarity before proceeding with a quantitative approach to build theory (e.g. Churchill, 1979; Lewis, Templeton, & Byrd, 2005). Secondly, qualitative methodology adds the contextual influences to revealing. The research question is aimed at identifying revealing implementation specific to the firm contexts. The study assumes that the implementation of revealing and the associated activities are different and are shaped by the actors within the firm. Therefore, it is necessary to study the phenomenon within the firm context and gather data from the participants of that specific context.

Table 3-1 presents the ontological and epistemological assumptions that guide the methodology of the study. The study follows the recommendations for a methodological fit suggested by Edmondson & McManus (2007, p. 1160);

Table 3-1: Methodological fit. Adapted from Edmondson & McManus (2007)

Paradigm	*Inductive*: Explore and develop concepts through fieldwork
Ontology	*Subjectivism*: participants create the reality
Epistemology	*Interpretivism:* the reality is context dependant and is based on the perceptions of the participants
Research Question	Open-ended enquiry to understand the revealing implementation in firms
Prior work	Relatively nascent theoretical basis for key concepts and relationships in revealing implementation
Contribution to literature	A theoretical contribution that provides a suggestive conceptualisation for revealing implementation and clarify the construct in focus; invites further work.
Methodology	*Qualitative*: Seek the meaning of concepts Collect qualitative data to interpret for meaning; Data analysis goal is to identify patterns via thematic content analysis through an iterative process

The aim of the empirical study is to explore revealing, specifically the implementation of it, in the empirical setting. For this study pose an open-ended enquiry into the revealing in multiple firm contexts. The idea is to examine the constructs that conceptualise the revealing implementation to derive meaning. The interpretive approach allows the researcher to understand the context dependant perspectives of the participants. The constructs and the relationships that conceptualise revealing implementation is under-developed and fragmented

that require the study refine and clarify for future work. Therefore, a qualitative approach is suitable for this study to investigate the constructs.

3.2 Case study method and multiple case study approach

This study specifically uses a multiple case study approach to conduct the empirical investigation of revealing. Table 3-2 illustrates key decisions made in the research design relevant to the choice of case study method. These decisions and the rationale are explained in the following paragraphs.

Table 3-2: Research design decisions and reasons

Design decisions	Reasons
Case study	Investigates the phenomenon in 'real-life' context; appropriate to address 'why' and 'how' enquiries in under-explored areas; creates rich understanding to refine constructs
Multiple case studies approach	Replicability of case study protocols to mitigates validity and reliability issues; provides multiple sources of data;
Theoretical sampling	Firms that fit the definition of OI; Innovative and committed to internal knowledge creations (engagement in R&D is a proxy used in innovation literature); mechanisms of revealing identified in the literature as indicators of revealing activities for later refinement; Purposeful sampling: To find relevant case sites that would demonstrate all forms of revealing forms; easy access to the sites; fits the NZ context

Qualitative case studies use one or more 'cases' to explore real-world phenomena within their contexts and clarify theoretical construct, measures and testable propositions (Eisenhardt, 1989; Eisenhardt & Graebner, 2007). A multiple case study approach is useful in this study to address the research questions of 'why' and 'how' revealing is implemented to understand and explain the revealing implementation in firms (Yin, 2018). Rather than focusing on the mere frequencies or incidences, the focus is to trace operational processes and produce rich descriptions of the revealing phenomena with the use of empirical evidence gathered through multiple sources of data (Baxter & Jack, 2008; Yin, 2018).

Such an approach is useful to get closer to constructs to understand relationships using context-based perspectives from the data sources (Siggelkow, 2007). The idea is to explain the interdependencies of the variables as well as defining the boundaries that formulate the constructs relevant to the revealing implementation (Eisenhardt, 1989; Gibbert et al., 2008; Ridder et al., 2009). Case studies provides a theory building approach that is embedded in empirically rich data that is accurate and testable (Eisenhardt & Graebner, 2007), and therefore

is further useful to conduct exploratory inquiry into clarifying the theoretical construct of revealing in OI (Churchill, 1979).

Multiple cases provide the richness needed to broadly explore revealing and the relevant firm specific concepts in question, and provide theoretical elaboration (Eisenhardt & Graebner, 2007; Yin, 2018). This further compliments the strength of the case study approach to penetrate deep into phenomenon in its real life context (Rowley, 2002; Yin, 2018). Such robustness in the investigation provide a strong basis for early stage theory development as well as for analytical generalisation (Gibbert et al., 2008). A multiple case study approach is suitable because it allows data collections from multiple cases providing the opportunity to study revealing implementation across multiple cases and firm contexts. Data from multiple sources enable triangulation of data (Eisenhardt, 1989; Gibbert et al., 2008; Kawulich, 2005; Yin, 2003). The conclusions are drawn based on a cross-case analysis to refine the existing understanding on revealing and increase the reliability and validity of the study (Eisenhardt, 1989; Eisenhardt & Graebner, 2007). The resulting findings from a multiple case studies, therefore, are comparatively generalisable than using a single case method (Benbasat et al., 1987).

There is no precise guide that dictates the ideal number cases in a multi-case study (Stokes & Perry, 2007). Eisenhardt (1989) argues that the number of cases should be determined based on the theoretical saturation – when the incremental learning starts diminishing (Glaser & Strauss, 1965). While an 'ideal' number of cases is not defined, a number between 4 and 10 is recommended for a multiple case method (Eisenhardt, 1989, p. 545). However, the number of case firms for this study was not merely a theoretically driven decision but a combination of theoretical as well as a pragmatic rationalisation. The number of cases was determined based on the access granted to case firms, time constraints and based on what is known and what can be learned with incremental cases (Eisenhardt, 1991). The five case firms chosen in this study provided insight into the phenomenon across the revealing spectrum (from extremely-open revealing to strictly-controlled revealing). The objective for this study was not to maximise the number of cases but to gather as much information as possible form the case firms that granted access, within a reasonable time frame to complete the study preserving the time-based relevance of the findings. The following section explains the sampling criteria.

3.2.1 Sampling strategy and criteria

The sampling strategy for this study follows a replication logic where the firms were selected based on the likelihood of providing theoretical insights necessary to address the research question (Eisenhardt & Graebner, 2007). Here the cases are treated as different experiments and are carefully selected for replicating results or the theoretical conceptualisation (Eisenhardt & Graebner, 2007; Yin, 2009). Furthermore, replication adds to the increased robustness of a multiple case method by providing better grounding, accuracy and relative theoretical generalisability, which counters a common complaint of single cases being too restrictive or abnormal (Yin, 2009).

The sampling is of a theoretical one rather than random or stratified (Eisenhardt, 1989; Eisenhardt & Graebner, 2007). A purposeful sampling method was developed based on the OI literature, and theoretical fields that grounds revealing, as well as the consultations from doctoral supervisors, peers in management research and industry experts (Eisenhardt & Graebner, 2007; M. N. Marshall, 1996; Patton, 2014) . The prevailing study context for revealing in literature are predominantly constrained to open source software (OSS). This is a key problem that this study wishes to address by drawing conclusions that are not restrictive to one context. Therefore, study used revealing mechanisms as indicators of revealing firms to identify case firms. The reason is to identify the most revelatory case contexts to understand the implementation of revealing behaviours and their relationships with the firm level factors (Yin, 2009). Consultations further showed that the study required cases that closely represent revealing firms in order to study the phenomenon in the field and thereby to extract the rich data that enables achieving the study objectives. Accordingly, a set of selection criteria was developed but due to the difficulties in obtaining access to firms (explained in 3.2.3), a pragmatic and flexible approach had to be followed in sampling (M. N. Marshall, 1996).

Having a set of case selection criteria helps not just to define what a case is, but also to clarify what a case is NOT (Baxter & Jack, 2008). Yin (2003) argues that a case can be bound by defining the boundaries through a) time and place (Creswell, 2014) b) time and activity (Stake, 1995) and c) definitions and context (Miles et al., 2014).

The criteria for case selection;

a) Being an innovative firm with internally developed innovative knowledge resources – firms that are actively engaged in R&D is used as a proxy to identify innovative firms.

b) Headquartered in New Zealand and is autonomous in NZ operations, especially the R&D activities of firms is based in NZ - Some of the case firms in this study had multinational presence but the off-shore partners are strictly sales agents and is not involved in the operations, especially in R&D activities.
c) Falling within the definition of OI as outlined in the previous chapter – Revealing is broadly defined as a knowledge outflow from a firm that does not generate direct financial inputs to the firm (Chapter 2). However, without the empirical insights from the site, one cannot decide if an outflow is with or without pecuniary benefits. Therefore, the study opted for firms having both inbound and outbound or outbound-only knowledge flows. Firms with inbound-only flows are omitted because they do not fall within the scope of this study.
d) Engaged in either one or more of the revealing practices - Literature identified four common practices that can be classified as channels for the outflow – Open source contributions, Publications (scientific, academic, internet or technical), collaborative innovations, and patents. Firms that only practice patenting were not considered for study due to the difficulty in identifying the motivations at the outset. The relevance of patents for revealing is only when they do not accompany a motive for appropriation (discussed in chapter 2). More importantly, it was considered uninteresting due to the wealth of research that already exist concerning its pecuniary and non-pecuniary motivations.
e) Firms that are commercial entities with financially driven motivations – this excludes Universities where most of the R&D activities take place and not-for-profit organisations. This also excludes crown research entities (CRIs) where the commitment disclosing the knowledge comes prior to commercial motivations. However, this study later involved one crown research institute due to their unique business model that provided the firm to have equally valued commercial objectives. Social enterprises were considered relevant since they are not explicit non-profits (e.g. Low, 2006) but only if they satisfy rest of the selection criteria.

3.2.2 The research setting - New Zealand

The firms that participate in this study are based in New Zealand (NZ). NZ is a small economy that is significantly innovative. Data from key surveys indicate that NZ is not far behind similar economies such as Denmark and Finland in terms of investment in innovation (MBIE report, 2018). New Zealand firms invest in developing and expanding innovation capacities in a small,

highly competitive domestic market and to address the challenge of imported products which can offer cost and quality advantages (Seidel et al., 2008). According to the Global Competitiveness Report (2019), New Zealand is the 19th most innovation-driven economy out of 141 countries.

Based on the Business Operations Survey (BOS) of 2011, Statistics New Zealand reports that almost half of the businesses (46% of the responded) are innovators (2011)[14]. Furthermore, 46% of the innovators invest more on growth activities and R&D, and 52% of expenditure on product development was on R&D. Even though the terms 'open innovation' or 'revealing' are not popular among the businesses in New Zealand[15], 75% of the innovative businesses have a porous innovation process where internal and external sources interact for innovation.

Prior studies have shown that NZ present a viable setting to investigate the OI landscape. Lee, Hwang and Choi (2012) study public sector OI in NZ classifying it as an 'early adopter' of OI along with several countries such as USA, Singapore, Canada, Japan and more. The study shows that OI practices in the public sector fares well with other leading countries. The authors identify Crown Research Institutes (CRI) of NZ as significant players that engage in revealing activities (S. M. Lee et al., 2012). However, the study emphasizes that revealing activities requires further attention in all the countries in their sample, including NZ. Daellenbach, Davenport, and Ruckstuhl (2017) investigates the collaborations between midstream science researchers and industry for innovation. Whittaker, Fath, and Fiedler's study shows that Small and Medium Enterprises (SMEs) of NZ benefits by collaborating for innovation (2016). These studies indicate that NZ has a significant OI landscape but revealing activities are among the less investigated aspects of OI.

In the recent year's attention and interest in opening up and sharing knowledge is growing in New Zealand businesses (StatsNZ, 2013). The annual innovation survey conducted by the statistic NZ, indicate that interorganisational collaborations are increasing. The practitioner conferences such as Open Source Open Society (OSOS) and Manufacturing and Design (MAD), further encourage and assist firms to open the firm boundaries to freely share knowledge externally and engage in collaborations. The participating firms of such conferences

[14] NZ reported a similar rate in 2018

[15] BOS does not use the terms 'open innovation' or 'revealing' in their surveys. Instead they use general terms such as knowledge sharing, knowledge inputs from outside or collaborative innovation to indicate porous firm boundaries.

indicated that NZ firms in all sectors, both public and private, are implementing some aspects of revealing. However, the current scholarly conversations on revealing, even in its limited capacity, do not include insights from firms in smaller but significantly innovative economies that implements revealing. Case studies and examples illustrating how firms have implemented revealing in an economy such as NZ could provide valuable insights to theory in terms of managing a valuable firm resource as well as develop business models applicable to similar economies.

This thesis, therefore, investigates a commercially focused range of firms in NZ involved in applied research such as CRIs (only ones with commercial intent for innovation and its outputs), high-tech equipment manufacturers, construction, and online services (internet). These case firms and their selection criteria are elaborated in the following sections.

3.3 Data collection

This section outlines the details of data collection and analysis. first, the details of accessing case firms is presented explaining the time-consuming process and hardships encountered in gaining access to case firms. This is followed by explaining the data sources used for the study namely, interviews and documents.

3.3.1 Case firms and participants

This study obtained data from five case firms that satisfy the presented criteria (table 3-3). The search for the case firms began in late 2015. First the researcher screened the publicly available websites where NZ companies are listed (e.g. Kompass) to generate a potential list of suitable firms for the study. Even though this produced a list of companies located in New Zealand it did not provide the insights into their innovation profiles or their knowledge outflow mechanisms. The information on how the firms engage in R&D and manage the knowledge was important for this study to identify relevant and ‘interesting’ case firms (Myers, 2013).

However, the study posed that the firms require to be engaging in one or more revealing activities, in addition to satisfying the R&D criteria. The information on the public domain was insufficient make informed sampling decisions that satisfied the selection criteria outlined in the previous sections. Therefore, consultations were sought from the supervisors, peers as well as industry experts to identify potential case firms. The researcher further had to rely on a combination of personal relationships and a lengthy search through news items and online

publications, institutions such as NZ Product accelerator[16] and Callaghan Innovation to identify potential companies. Additionally, the researcher participated in practitioner-based conferences, both to identify potential case firms and to form connections that could lead to access.

Table 3-3: Case profiles.

Case firm	Description	Innovation/s	Industry/ business type	Company size
EVD	Provides energy saving and management solutions to the construction sector	Zero Energy houses, energy saving solutions	Constructions – energy solutions	5 permanent employees 10 interns and contractual employees
LMO	Promoting collaborations through online platforms	Online platform for collaborations, distributed management style, decentralised decision making	Online solutions (IT)	15 worker members (Changed since mid-2017)
TTR	Radio and communications solution provider	Radio communications, hand-held communications devices, improved communication protocols	Radio and communication equipment Manufacturing	650
SMX	Assisting forensic investigations	Unique software to identify DNA and RNA strings in forensic investigations	Scientific research	100+
RQL	Air quality measuring equipment and solutions	Miniature measuring equipment, installation designs	Environmental quality sensor manufacturing	600+

First conference took place in mid-2016. Open source open society (not limited to open source software) hosted firms from New Zealand that has open knowledge sharing in some form, and at times find it challenging. The term ‘open source’, in the title referred to any firm that adopts open source principles for knowledge sharing and openness, and not the OSS business model. Participants of the conferences ranged from large corporates to small start-ups all who share and understand the idea of voluntary knowledge outflows for non-pecuniary returns. Two of

[16] NZ Product Accelerator assist, and fund applied research in product and process development in Materials industries; is based in the University of Auckland.

the case firms (EVD and LMO) were identified through this conference. The consultations sought from industry experts provided leads to two firms, SMX and TTR, and was contacted in late 2016. Both firms were approached via personal contacts. The final three firms (RQL, TER, MLR) were contacted through connections made at the Manufacturing and Design Conference, 2017, which is an Industry University collaboration.

3.3.1.1 Access to data

Gaining access to case firms was a lengthy and difficult process. Based on the information in the public domain, industry experts and the conference participations, the researcher made initial contacts with more than ten potential case firms between late 2015 and later 2016. The initial contacts were followed up within a reasonable time frame. However, only eight firms who were contacted via personal relationships responded to the request. Except EVD and LMO, all firms consumed a lengthy time varying from one to four months, to respond. A major reason for the delay in responses or the reluctance to participate is the relatively small scale of the business community in New Zealand; Firms are overwhelmed with requests to participate in studies, which affects their willingness to do so (c.f. Chetty, 1996).

Out of the eight favourable responders, one firm rejected participation after the initial meeting due to difficulties in committing time and resources necessary to participate. Two case firms were eliminated from the study due to insufficient data and being unable to identify additional data sources. Data from the five case firms outline in Table 3-3 completed participation in the study. A detailed description of each firms is provided in Chapter 4 with the case narratives.

First meeting with the inside ‘agent’ provided the necessary information to decide if the case satisfy the criteria and relevance. After the formal consent to proceed with the study, potential interviewees were identified. The agent provided the inside information to decide which participants could be key informants. Each interview was 1 hour to 1.5 hours long depending on the availability of the participants. Observations of specific events were not permitted in all firms due to time and resource constraints. However, general natural observations were conducted in all firms while waiting for interviews, and in one firm, by spending a day in the firm. Document data were obtained through the agents, interviewees and through internet.

3.3.2 Sources of data

This study used interviews, documents and field notes to collect empirical evidence required to address the research question (Denzin & Lincoln, 1998; Eisenhardt & Graebner, 2007; Yin, 2003).

3.3.2.1 Interviews

Interviews are one of the most important and widely used method of collecting qualitative data (Myers, 2013). Interviews provide access to rich data from people from various backgrounds which enables the researchers understand a phenomenon from multiple perspectives and varying depths (Myers, 2013). This study followed a three step process for the interviews (see Dilley, 2000) – Protocol development, interviewee selection and finally being reflective in the interview process.

First, an interview protocol in the form of semi-structured interviews was developed based on the existing literature guided by the research questions and aims. These open-ended questions broadly dealt with basic background information of the interviewee (e.g. role in the organisation), internal innovation and knowledge creation, revealing implementation and strategies, capabilities of the firm, culture and values related to knowledge sharing, and outcomes that are potential, perceived or already received. While some structure is needed to maintain consistency across the multiple cases, highly structured interviews 'blind' the researcher to the site (Miles et al., 2014; Rowley, 2002). Having open-ended questions further provides the flexibility to expand on the response and ask probing questions (Rowley, 2012). For example, the question 'how does the knowledge sharing (open sharing) activities impact your firm?' probes the interviewee to explain what the impact is in detail rather than providing simple yes or no responses. Follow up questions can be used to derive examples that elaborate the impact. It is also noteworthy that the questions do not use 'revealing' as a term but instead use 'knowledge sharing' and 'open sharing' in order to prevent confusion – avoiding jargon (Rowley, 2012). The informal meetings with practitioners prior to the research showed that 'Revealing' as a term for non-pecuniary knowledge outflows is not popularly known by the industry. Appendix A presents the interview protocol used for the study. Even though a semi-structured guide was used, interviews are essentially conversations (Denzin & Lincoln, 1998) and therefore were allowed to follow their natural course within reason (Myers, 2013).

Second is to identify and understand the interviewees. Interviews were conducted with relevant employees that perform varied roles relevant to knowledge creation, sharing and management from senior management (CEOs, co-founders, Directors) and operational levels (R&D managers, project managers) to limit bias (Eisenhardt & Graebner, 2007). The interviewees were identified through the guidance of an 'insider' (Denzin & Lincoln, 1998). However as a general guideline members of the senior management (CEOs, Directors, co-founders, etc), head of R&D/innovation activities, and R&D project managers were identified as more suitable

participants for this study because they are familiar with the innovation process and more involved in the revealing activities according to the prior studies (Eisenhardt & Graebner, 2007) (for examples see Hargadon & Sutton, 1997; Henkel et al., 2014). **Table 4-3** presents the profiles of the interviewees of each firm. Prior to the interviews, the researcher conducted some background research based on publicly available sources to get insights into their professional profile in order to tailor the questions accordingly. Furthermore, interviews are influenced by the social context in which they take place (Denzin & Lincoln, 1998). Therefore, being aware of the differences of the participants was important when preparing for the interviews.

The interviews were conducted in the respective firm premises. All interviews except two were recorded via an audio recorder and transcribed later. The interviewees of the unrecorded interviews intentionally slowed the conversation speed to allow note taking and repeated the responses where necessary for accurate note taking.

Finally, self-reflective interviewing helps to reduce the amount of errors that are being made during interviews which may result in poor data quality. Interviews require listening with 'many ears' (Dilley, 2000). The interviewer simultaneously needs to actively listen to responses, be observant of the body language, take notes, and understand the responses to ask to follow up or clarifying questions. A nervous and inexperienced researcher may not be able to achieve all the 'listening' during the first interviews. This was true to this study as well. The first few interviews showed rushed discourse, unnecessary interruptions and not being attentive enough to sought clarification or explanations during the interview. However, these issues were mitigated by contacting the participants for clarifications further through the participants checks of the cases.

Table 3-4: Interviewee profiles

Case Pseudonym	Interviewee Pseudonym	Profile (Actual)
EVD	E-Andy	Cofounder • responsible of communications
	E-Ben	Co-founder • responsible of technology
	E-Cathy	No official title • Prepares news items, scientific articles, and all kinds of communication
LMO	L-Dan	Co-founder • content producer
	L-Eileen	Agile instructor • workshop host; team coach

Case Pseudonym	Interviewee Pseudonym	Profile (Actual)
	L-Fiona	Translator • workshop facilitator; user support
	L-Greg	Director • business development manager; coordinator
	L-Halle	Accountant • Quantifying the outcomes of sharing
	L-Isaac	Senior developer • software architect
	L-Joanna	Director • strategist - (US)
TTR	T-Ken	R&D manager • involved in innovation process and revealing
	T-Larry	Chief technology officer • involved in the revealing
SMX	T-Mike	Forensic R&D manager • involved in innovation process
	T-Nick	Business Manager • revealing decisions
	T-Patrick	General Manager - business development • revealing decisions; identifying commercially viable knowledge; innovation projects
	T-Ronald	Chief scientist - R&D • scientific publications, Uni. Collaborations
	T-Steve	Business development team • involved in commercialising innovations
	T-Tod	Business development team • involved in commercialising innovations
RQL	R-Vince	Co-founder and CTO • Decision maker of all revealing activities
	R-Will	VP Product development • innovations and knowledge creator
	R-Zander	VP Commercial • managing the commercial aspects

The researcher being a non-native English speaker further made it difficult at times to understand the conversations with clarity until the transcriptions were made. However, being self-reflective and self-critical allowed the researcher to understand the flaws and minimise the errors with every incremental interview. The interviewees provided clarifications and explanations post-interview when needed to fill the gaps found in interviews.

3.3.2.2 Documents

Documents are written material and artefacts that provides insight into a phenomenon in addition to interviews and field work; which are usually material that others develop (Denzin

& Lincoln, 1998; Myers, 2013). Documents relevant for the study included written material such as web sites, blog content, as well as corporate records such as collaborative research agreements, knowledge databases, etc., photographs, and annual reports, that recorded important aspects of revealing such as planning revealing activities, organising internal knowledge (modularising), as well as actually revealed content (e.g. in blog posts) (Myers, 2013).

Table 3-5: Documents sourced from firms

Case firm	Types of documents
EVD	Blog posts sharing knowledge on the innovation Press releases on communications campaigns (revealing events) Material used to plan communications campaigns
LMO	Handbook for collaborations (available online) – revealed content News items on revealing workshops Advertising material promoting revealing LMO blog posts
TTR	IP policy Annual reports Articles written by the R&D manager on collaborations News items portraying revealing efforts of TTR
SMX	Contractual documents used in collaborations – Universities IP Management policy News items covering the collaborative efforts for innovation
RQL	IP management policy Blog posts and company developed case studies

Furthermore, documents can fall under three categories suggested by Payne and Payne (2004) – Personal documents like field notes, case write-ups, written by participants or employees of the firm (does not include notes and write-ups of the researcher); private documents such as research agreements, knowledge databases, memos, internal photographs, intranets; and Public documents like annual reports. This ensures that documents if taken as a single source, eliminates the bias of the text where the meaning is made through reading and writing rather than in the text (Denzin & Lincoln, 1998).

Table 3-5 presents a summary of all the documents sourced from case firms. Apart from the documents sourced from public domain, the rest were shared with the strictest confidence by the firms. Documents from the internet required careful screening informed by framework,

research questions and the aims of the study to identify material that are relevant (Myers, 2013). Even though this is a time consuming process, it is much needed to identify documents which can enhance the richness of the case and to support data triangulation in analysis (Bowen, 2009).

3.3.2.3 Observational field notes

Field notes are an essential component in qualitative research (Myers, 2013; Phillippi & Lauderdale, 2018). Reflexive field notes were used across the data collections phase to keep notes on observations at the field. Direct and participant observations are used in the study to understand activities, behaviours and incidents that are relevant to the revealing activities. Notes on observations provide systematic insights into events, behaviours and artefacts in their natural setting (C. Marshall & Rossman, 2010). The study used observations to identify events or activities in the revealing process that are routine to the firm that may not realise to articulate at the interviews. Even though field notes were kept recording the direct observations, Firms except EVD and LMO, did not permit observing specific events that provide direct insights such as revealing activity planning sessions, R&D group meetings, and specific collaborative meetups. Therefore, observational field notes are not used as a standalone method in this study but rather to support the analysis of the data gathered to interviews and documents. However, the researcher prepared observational schedules necessary in case the opportunity was given.

Observation allows the researcher to participate and interact to some extent with the observed during the observations in order to gain the 'inside' view (Kawulich, 2005; Myers, 2013). During observations, researchers get the opportunity to 'hear unofficial story, informal conversation and extended period of engagement' (Myers, 2013, p. 137).

The first step in observation is the selection of the setting (Angrosino, 2011; Denzin & Lincoln, 1998). For this study the setting was predefined by the case-site and the context (Yin, 2003). If the researcher is not part of the setting (as it is the case in many participant observations), the second step is getting access. Depending on the chosen setting, researchers either may be allowed pass through at will (e.g. public places, commons, etc.) or may require a gatekeeper to gain access required (Denzin & Lincoln, 1998) usually ranging from Board members, CEO s to secretaries, PAs, etc. Since this study required the researcher to gain formal access for all data collection methods, this was done during the initial meetings with the inside agent who gave formal consent to proceed only in the case of EVD and LMO. Other three firms denied access to observe specific events.

According to Spradley (1980) Stages of observations takes the form of a funnel (Denzin & Lincoln, 1998) – starting out broad but getting more focused with repetition (Angrosino, 2011). The initial observations may be descriptive and unfocused in nature (Denzin & Lincoln, 1998; Emerson et al., 2011). what is central to the study usually becomes clear after repeated observational exercises and sometimes with further clarification from the members of the community being observed (Angrosino, 2011). However, a structured approach is recommended to conduct relevant observational data (Myers, 2013) in a multiple case study approach to maintain some form of consistency for cross case analysis. Even though one cannot predict or structure the observational activities a planning session that outlines the types of information to look for guided by the framework and research questions is useful (Jackson, 1987). The observations guide used for this study is attached as Appendix B.

However, it is vital to record 'everything' at first, especially the first impressions, in order to be retrieved later for screening and analysis. The first impressions, which are often insightful, are vital to be recorded in the time of occurrence, because with time, once the observer becomes comfortable in the setting, these impressions (or the incidents that triggered them) begin to dilute and become commonplace (Emerson et al., 2011).

It is often necessary to become acclimatised to the setting to overcome the 'culture shock' (Angrosino, 2011) – being overwhelmed by the new, and unfamiliar surroundings. Once the researcher become familiarised with the setting, he/she can identify the significant, unexpected or interesting incidents to record (Emerson et al., 2011). The identification of such events depends on a combination of the aims of the study, personal experiences and even intuition of the researcher.

Even though the researcher did not participate in the activities as an insider in a strict sense, some interactions took place during the activities that were observed. However, the intensity of the participation varied across the case firms. While some firms welcomed interference for clarifications or questions, some others preferred the observer to be silent during the activities while acknowledging their presence in the room. However, questions and clarifications were welcomed after the fact. Two case firms did not allow specific event observations at all due to time constraints from their side. In such instance, researcher had to rely on informal discussions with non-participants and more document data to gather necessary information (ref.).

Even though there is no universally accepted format for observational data recording (Angrosino, 2011), researchers use a variety of methods from highly structured checklists and

tables to free-form narrative. In this case, the researcher followed a template[17] (Table 3-5) for note taking during the observations (Denzin & Lincoln, 1998; Miles & Huberman, 1994; Myers, 2013).

Table 3-6: Template for field notes, Adapted from anthropod.net

File name	Records the general attributes of the activity.
Title	
Date	
Venue	
Description of Activity	This section provides an account of what happened. The general 'who, what, when. Where, why and how' approach was used to develop an accurate verbal snapshot of the occurrences. These descriptions were kept separated from analysis as much as possible.
Reflections	For specific notes reflecting on how the researcher may have influenced certain activities, things that could have been done differently or things that deviated from the plan. Also, reflections on what could change in the next iteration comes here.
Emerging questions	Potential clarifications to be requested, links to other data sources that were immediately visible (E.g. interview points that corroborate or contradict the actions), etc.
Future actions	For notes on any specific actions to be taken
Potential informants	List of persons that could shed light on the questions or clarification needed regarding the observation.

3.3.3 Establishing the rigour

Gibbert et al., (2008), extending works of Cook and Campbell (1979) and Yin (2003), presents four criteria that satisfies the rigour of case study research.

Table 3-7: Summary of validity and reliability checks for the study

Construct validity	Triangulation	Multiple sources of data, rich case write-ups, participant checks for accuracy, corroboration with theory.
	Chain of evidence	Description of case selection, participant selection and interview and observational protocols (Appendix B).
External validity	Case selection protocol	A theoretically informed case selection process
	Cross case analysis	Using multiple case studies to observe the phenomenon thus allowing analytical generalisability
Internal validity	Establishing a framework	Literature-based framework that guides the empirical work
	Theory triangulation	Patterns and other findings are corroborated with multiple bodies of literature for reliable interpretation
Reliability	Research database	Maintaining a database of all the textual, audio and visual data in NVivo12 for easy access, retrieval and future reference.

[17] The template was developed by Lorena Gibson at Anthropod.net (Gibson, 2013).

a) *Construct validity* establishes the operational measures (Gibbert et al., 2008; Rowley, 2002) by establishing a clear chain of evidence and data triangulation (Yin, 2003). A clear account of the data collection process is provided in the following sections that outline the case selection criteria as well as the multiple data collection techniques used. It further explains the procedure followed to gain access to the case firms and the ethical considerations. This account provides reflective notes on the circumstantial actions performed and how they altered the course of the data collection process. Finally, the data analysis phase explains the measures taken to validate the data by following a meticulous coding process and writing up cases. The descriptive case write ups were submitted to the key informants for review.

b) *External validity* ensures the analytical generalisability (Eisenhardt, 1989; Rowley, 2002; Yin, 2003). In a qualitative analysis process data are a co-construction of meaning between the participants –usually the practitioners– and the researcher (Amabile et al., 2001; Gibbert et al., 2008). Hence, qualitative case studies do not aim for generalisation in a statistical sense (Gibbert et al., 2008) but they still to satisfy the reliability and validity measures to maintain the rigour that helps to claim the relevance (Scandura & Williams, 2000). Therefore, apart from following a theoretically and empirically informed rationale for the case selection and establishing the study context, this study uses cross-case and within case-analysis to aid identifying the patterns and maintain analytical generalisability (Eisenhardt, 1989).

c) *Internal validity* refers to the causal relationships between the variables and the results (Gibbert et al., 2008). The empirical work is based on a framework founded on existing literature and theoretical perspectives that enables the data to be scoped and kept relevant. The coding process enables the pattern identification (Creswell, 2014). Finally these patterns and other findings are triangulated with theory and the framework for interpretation (Yin, 2003).

d) *Reliability* is to ensure transparency and replication (Denzin & Lincoln, 1998; Rowley, 2002). Establishing the case selection criteria ensures that while the sampling is theoretical, it also provides a suitable protocol for a replication. Furthermore, this study maintains a database of all the data – notes, case descriptions, transcripts and coding procedures which could be used for future replications if necessary. Keeping records of the procedures provide an interested party to understand the process followed in this study.

3.3.4 Exiting field work

Researchers usually exit the field when the data reaches saturation (Eisenhardt, 1989). However, it is not the case for this study. Rather, the researcher exited field due to difficulties in getting relevant participants or finding more case firms. This decision was following the recommendation of 'coming to terms with an appropriate time to leave' (Michailova et al., 2014, p. 143). First, difficulties of identifying more participants within case firms was challenging. For instance, several 'agents' from the participating case firms left the firms six months after the primary data collection process started. Therefore, identifying new participants was a difficult task especially in the case of TTR. Gaining access to more case firms tendered a time-consuming task. More time spent in the field would have delayed the process of the study and may make the RQs and findings obsolete by the time it completed. Therefore, 'coming to terms' to exit field at this point was fitting in order to proceed with the rest of the empirical process.

Once left, contacts were maintained with the key informants to inform of the progress. These relationships led to one firm inviting the researcher to make a presentation to the firm on OI. Furthermore, constant updates were sent to the key informants about the progress.

Two limitations were identified in the empirical process. First, the inability to gain observational data was a limitation. If allowed, observation would have provided insights to the revealing process in the firms that are routine and therefore implicit in nature. Due to the sensitive nature of innovation processes in firms, only two firms out of five allowed substantive observations in the firm and in specific events that are related to innovation activities. As a mitigation tactic, more organisational documents that explain revealing activities such as collaborative agreements, informal texts such as internal and external blog posts, published interviews, were included in the analysis and subsequently used participant validation for cases to provide the opportunity for the participants to add, clarify or modify the data presented. Second, the measures had to be taken to mitigate the effects of the researcher (Creswell & Creswell, 2018). Field notes, and supporting archival data such as third-party reports, were used to counter contextual biases that the researchers have that affects the study.

3.3.5 Ethical considerations

As with any field-based research this study had to consider the ethical concerns due to the nature of the study (Denzin & Lincoln, 1998). Prior to commencing the empirical phase of the research, this study sought and received approval from the Ethics Committee of University of

Auckland (UoA). The main ethical concerns were related to the confidentiality of the firms and individuals that would be part of the study. Concerns also included the use digital recordings in interviews, and the participants' right to refuse recording, or remove from participation altogether even if the consent was given earlier.

In order to address these ethical concerns, a description of the study, and protocols and procedures that would be followed, were given to the firms and individual participants (Appendix C) prior to gaining formal consent allowing sufficient time for clarifications and discussions. Formal consent forms outlined their right to remove from participation at any stage, to refuse audio records, to refrain from participating in observed events (Appendix D). These concerns were revisited prior to interviews and observations in order to ensure the participation is both voluntary and through informed consent. Transcripts of interviews were provided to participants who requested.

Furthermore, the study uses a coded process to refer to the firms and the participants to ensure anonymity. Even though the details of the firm and participant profiles are actual, the names used are codified to prevent identification.

3.4 Data analysis

Qualitative research relies on words to create the text (Rynes & Gephart, 2004); gathered via many different form such as interviews, observations, documents data, etc. this means the researcher ends up with a huge amount of data. Therefore a systematic approach is required to reduce the data into meaningful and manageable forms that can be used for interpretation (Myers, 2013). Creswell (2014) suggests a hierarchical process to analyse qualitative data (fig. 3-1). Although the process shown in the figure suggests linearity, it is far from it and is not always followed in the same sequence. It is more of a representation of the actions performed at various stages of the data analysis process and the actual process is iterative and cyclic in nature.

This approach further agrees with the recommendations of Miles et al., (2014). Following these recommendations, the analysis has three key stages: data preparation and reduction to select and simplify; data display to organise the raw data to support recognition of patterns and themes, and finally drawing conclusions through within-case and cross-case analysis.

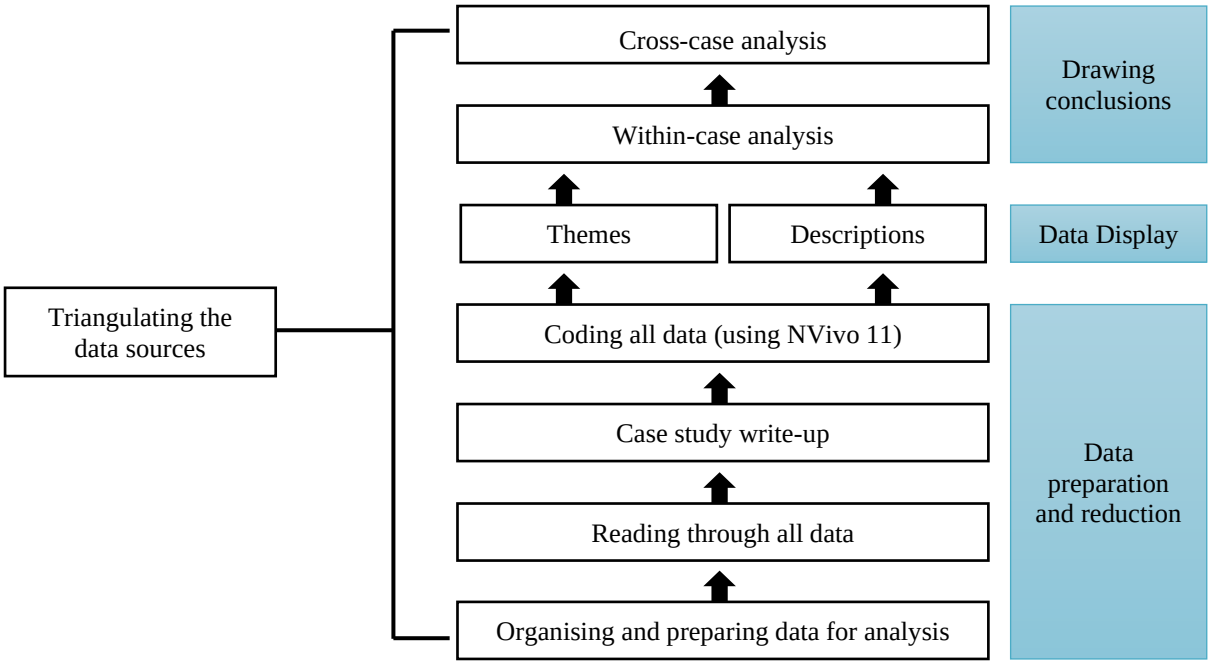

Figure 3-1 - Qualitative data analysis process (Adapted from Creswell (2014) and Miles et al., (2014)

All the data collected through interviews, observations and documents were converted into text format (Miles & Huberman, 1994; Myers, 2013; Rynes & Gephart, 2004) in order to achieve two interrelated objectives. First, the text format helps to develop the descriptive case narratives which tells the story of each case firm in a precise yet concise manner. Furthermore, the case narratives reduce and maintain the data within the scope of the study. Being able to revisit the transcripts and field notes ensure that an accurate representation is made through the case write-ups while enabling the researcher to reflect on their own bias in interpretations (Myers, 2013). Secondly, and simultaneously, data in text form helps the coding and triangulation process.

3.4.1 Coding and patterns

Coding is the process of organising the empirical data into categories known as codes/nodes. A code is a word or a phrase that "symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute" for a portion of textual or visual data (Saldana, 2016, p. 3). The coding process of this study is similar to the process illustrated in figure 3-2. In order words, the coding process 'reduces' the large chunks of data into meaningful yet shorter and manageable labels which allow the researcher to base the interpretations and comparisons. By reducing the data into codes, the process "summarises, distils or condenses" the data into categories that "value adds" to rather than diminishes the story (Saldana, 2016, p. 5). However, once again, this process is not sequential or linear and has numerous repetitions and iterations of returning to raw data and back during any phase of coding.

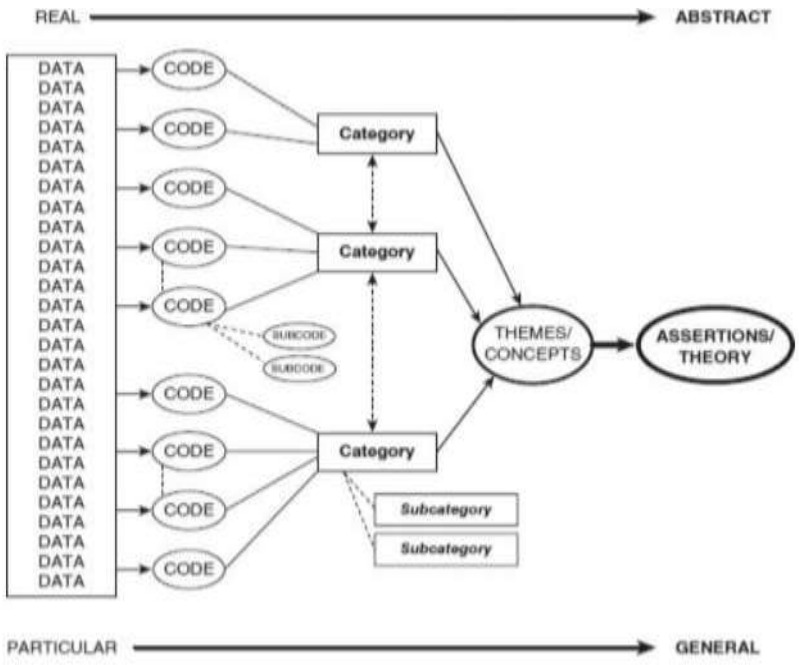

Figure 3-2: Coding process. Reproduced from Saldana, 2016

The coding process began with preliminary coding on one case to 'feel the data' (Saldana, 2016) where the preliminary codes are derived from the research questions, conceptual framework and theoretical perspectives. Examples of preliminary coding used in the study is given in table 3-8. These codes are developed through the intensive literature review and the framework developed in chapters 2. For example, revealing behaviours are derived from the works of Alexy, George, & Salter (2013) Boudreau & Lakhani (2015), Henkel (2006), and Henkel et al., (2014). These works suggest that firms strategise revealing by controlling access or content. Hence the subcodes were assigned to identify text that express meaning relevant to these codes.

Preliminary coding assigned large chunks of data into broad categories. This helped to scope the data for developing the case narratives.

Table 3-8: Preliminary codes developed from theoretical perspectives

Background:	
ATTR:	Descriptive details such as case name, background, history, milestone event, revealing activities,
INNO:	Innovation related data: Innovative knowledge of the firm, innovation projects relevant to the study, key personnel etc.
Category: Drivers	
OUTCOME	potential outcomes
CHARA	Firm characteristics

E. PRES	External pressures
Category: Knowledge (Sub-codes for INNO.KNW)	
TACIT	Tacit knowledge
EXPLICIT	Explicit knowledge
Category: Revealing behaviours (sub-codes for REV.BEH)	
ACCESS	Access controlling
CONTENT	Content controlling
Category: CAPABILITY	
MOD	Modularity
DECON	Decontextualisation
ABSORP	Absorptive capacity
DESORP	Desorptive capacity
TIME	Timing
Other codes:	
CHALLENGE	Challenges encountered when revealing
BARRIERS	Barriers that prevented revealing

Once the preliminary coding stage is carried out, the subsequent coding followed a three-stage process (Miles et al., 2014; Saldana, 2016) (table 3-9) - First cycle coding, transition and second cycle coding.

Table 3-9: coding stages and types

	RQs; literature review; theoretical concepts		
Sources of data	Interviews	Documents	Field notes
First cycle coding	- Descriptive - In Vivo - Process - Values	- Descriptive - In Vivo - Process	- Descriptive - Simultaneous - Values
	- Transition – cleaning the first cycle coding		
Second cycle coding	- Pattern coding - Axial coding		

In the first cycle, a combination of descriptive, In Vivo, and process coding was used to identify broad topics relevant to the thesis concepts. Descriptive codes such as ‘capability’, ‘revealing activity’, ‘innovation project’ was used to put ‘labels’ on identify elements of the data that are essential for the study – acting as ‘hashtags’ in the coding process (Saldana, 2016). In Vivo codes allowed to identify activities, meanings, processes, that were not explicit in the literature. These codes use the language of the participants to assign label to data points. Such codes are

useful to identify emergent themes from the data. For example, ‘find risk-reward balance’, ‘assign IP-buckets’, ‘peer-validation’, and ‘long-term strategy’ were used in the study as In Vivo codes. Finally process codes were used to code the actions. These included codes such as ‘sharing based on trust’, and ‘peer-reviewing’. Values coding captured the perspectives of the participants specially to capture the cultural and ideological views relevant to sharing. These included codes such as ‘mission-led’, and ‘adhere to founding principles’.

In order to minimise the clutter by reducing synonyms and redundancies, selected codes were used repeatedly. During the transitional stage, codes were subsumed to broader codes, or categories, essentially cleaning up the first cycle codes. Eclectic coding is recommended at this stage to transition the data from first order cycle to second order (Saldana, 2016). However, significant eclectic coding did not take place in this study. Instead, the transition stage involved eliminating redundancies that were overlooked during the first coding cycle. Second cycle coding looks for patterns in the preliminary codes and create subgroups. Pattern coding and axial coding were used at this stage to identify emergent themes through In Vivo codes, and condense the data smaller analytical units and reassemble to create categories (Miles et al., 2014; Saldana, 2016; Spiggle, 1994).

Data – lower levels of abstraction ⟶		First order category – high level abstraction
“It's this connectivity that provides us with access to knowledge and expertise that will allow us to continue to innovate and evolve to meet the needs of our clients.”	Access to knowledge, Access to expertise, Need to continue innovation	Revealing to gain access to resources necessary for internal innovation
“University collaboration is mainly to have a flow of knowledge into the company”	Collaborations Access to knowledge	
“The key to innovation is people. Our relationships with universities, government, industry partners as well as our clients are, therefore, critical to our success. Through the strength of these relationships we are able to attract the best people to work for us and with us.”	Key to innovation is people, Needing human resources, Collaborations	
“The product and solution partners are involved in providing the capabilities that we don’t have.”	Partnerships Providing capabilities Need capabilities	

Figure 3-3 - Example of the abstraction process

Figure 3-3 shows an indicative example of abstraction process used in the study to achieve the first order categories. Even though only three stages are shown, this process encountered numerous coding stages and iterations to achieve the abstraction shown. Analytical notes and annotations where kept during the coding process to keep note of the thinking process. These notes were instrumental in the analysis process to identify emerging themes and concepts (Miles et al., 2014; Saldana, 2016).

The analysis process followed an inductive approach to allow new categories and themes to emerge from the data (e.g. Fereday and Muir-Cochrane 2006). The main objective of such an approach was to derive meaningful themes that help to theorise the interplay between revealing behaviour and related concepts (Miles et al., 2014). However, this is not to be confused with a grounded theory approach (Gioia et al., 2013) where the data provides the starting point for the concepts and themes to emerge. Instead, this study began with the conceptual framework and concepts that guided the coding and analysis. The subsequent coding, abstraction and aggregation process too was an iterative one where constant consultation took place between data and theoretical perspectives. However, being inductive at the analysis process allowed new categorisations and themes to emerge. For example, the abstraction process derived 'induce industry advancement' and 'internal advancements' as second-order categories. Both are 'potential outcomes' from revealing as shown in the literature. But these categories add nuance to the term 'outcomes' by indicating where the benefit is immediately focused; one is focused on the industry (external) and other, the firm (internal). Hence the subsequent aggregating themes differ. The former is driven by altruistic motivations, and the latter by internal goals. This process of coding, abstraction and theming process presented insights to theorise the relationships between concepts and revealing behaviours.

The coding process derived 28 first-order categories which were subsequently grouped into second and third-order. The data structure table (table 5.3) is and the resultant analysis is presented in Chapter 5, section 5.3.

For this study, NVivo 12 was used to aid in the coding and analysis process along with Microsoft excel as a supporting tool. All the text along with their corresponding audio or visual source is imported into NVivo 12. This also acts as the database that keeps the records of all the data for future reference and uses if necessary which ensures the reliability measures are met. Once the coding was transitioning to the second cycle, the nodes were imported to MS Excel to arrange and rearrange during the second cycle for convenience and flexibility in coding and re-coding attempts.

3.4.2 Validity and reliability

This study uses three reliability and validity checks – method triangulation, member checks and the choice of extreme cases (Miles et al., 2014). First, method triangulation is a requirement to ensure construct validity (Creswell, 2014; Miles et al., 2014; Yin, 2003). Triangulation is the act of using multiple 'viewpoints' to analyse data bearing on the same phenomenon (Jick,

1979). It enhances the trustworthiness, dependability and credibility of data by converging different data sources, participant checks and rich descriptions (Creswell, 2014). For example, in EVD, the data are obtained through three interviews, field notes of observations and multiple documents sourced from their blog and workshop material. The coding process uses consistent codes to analyse data across the multiple sources for each concept of the framework, in search of patterns and themes. Finally, these findings are compared with the literature and theoretical perspectives for interpretation. A visual representation of the triangulation method used in the study is shown in figure 3-4.

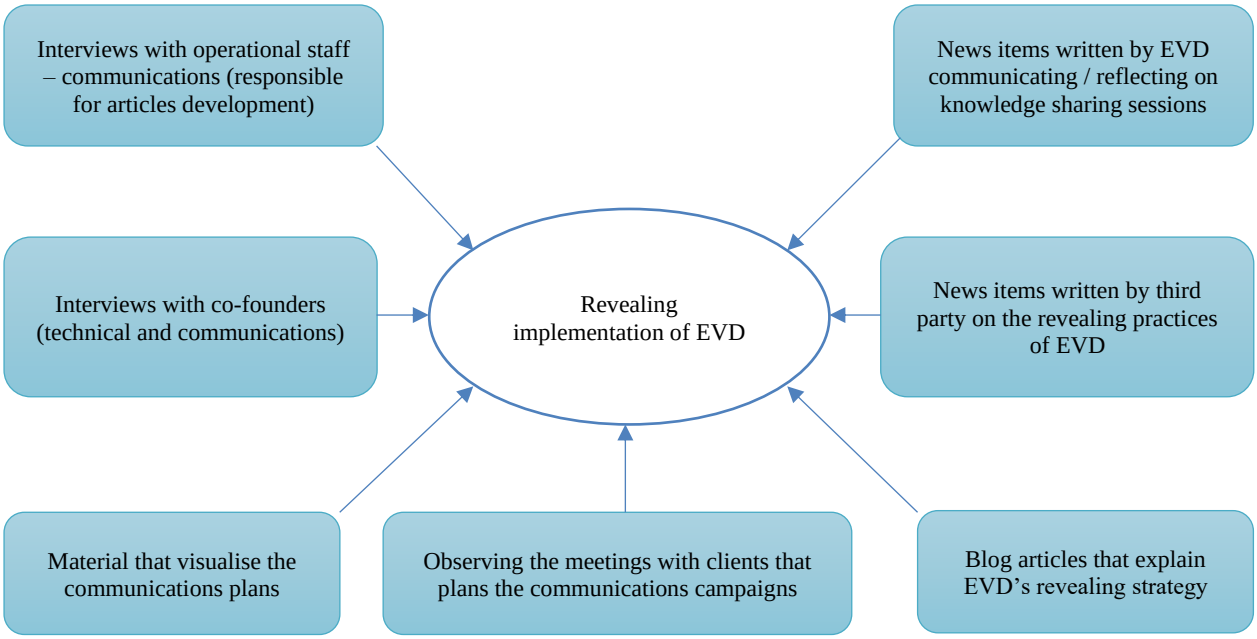

Figure 3-4: Example of triangulation

Second, the case write-ups that are based on the data are sent to the key informants of each firm for accuracy checks. Case write-ups provide the rich descriptions that enable the data to be scoped and presented in a concise yet meaningful manner. The write-ups are influence by the researcher's point of view considering the methodology used and the type of data analysed. Member checks essentially send the data back to the participants to validate the researcher's predictions (Burnard et al., 2008; Miles et al., 2014).

Considering the qualitative nature of the study, the time constraints and practical concerns, and the debatable nature of evaluating two qualitative perspectives, this study did not use inter-rater reliability as a reliability check (Burnard et al., 2008). However, the researcher had discussions

with peers and consulted an NVivo expert during the coding process to ensure that the appropriate checks are made, and the right procedures are used during the analysis.

Finally, the study used a purposeful theoretical sampling method to identify case firms that fit the extreme cases within reason (Miles et al., 2014). For example, the study requires firms that reveal knowledge in one or more means. Therefore, including a firm that does not reveal is not appropriate and is irrelevant to the study. However, this study includes firms that are extremely open (e.g. EVD) and that are extremely restrictive (e.g. TTR) in the revealing activities to gain a balanced perspective across multiple contexts to derive the conclusions.

3.5 Chapter summary

This presented the research design applicable to the study. The study assumes a subjective world view with an inteprevist epistemology that leads to a qualitative approach. The study specifically uses multiple case study approach to understand and explain the revealing implementation in multiple firm context by aiming to integrate participant's context-based perspectives. A summary of key methodological choices made in the study are presented in table 3-9.

Table 3-9: methodological decisions made for the study

Key decisions/actions	Descriptions/Procedures
Research approach	Qualitative
Methodology	Multiple case studies
Data sources	Interviews, observations and documents/ textual artefacts
Unit of analysis	Revealing implementation
Analysis strategy	Within case and cross case
Validity checks	Data triangulation, chain of evidence, case selection protocols, establishing framework and within and cross-case analyses
Reliability checks	Maintaining a research database

Chapter 4 presents detailed descriptions of the case firms and the respective case narratives used for the analysis presented in chapter 5.

CHAPTER 4 CASE DESCRIPTIONS

4.1 Introduction

The case descriptions that follow detail the narratives of the participating firms, providing rich descriptions to support the analysis of empirical findings (Eisenhardt & Graebner, 2007; Yin, 2018). Table 4-1 presents a summary of the case firms.

Table 4-1: Case profiles summarised

Case firm	Description	Innovation/s	Industry	Size	# Interviews	# Documents
EVD	Provides energy saving and management solutions to the construction sector	Zero Energy houses, energy saving solutions	Construction	5 permanent staff; 10+ temporary staff	4	15+
LMO	Promotes collaborations through internet-based platforms	Online platform for collaborations, distributed management style, decentralised decision making	Internet	10+; many volunteers	5	15+
SMX	Assists with forensic investigations	Unique software to identify DNA and RNA strings in forensic investigations	Applied research	100+	6	10
RQL	Provides air quality monitoring equipment and solutions	Miniaturised measuring equipment, installation designs	Air quality sensors	30+	5	15+
TTR	Radio and communication solutions provider	Radio communications, hand-held communications devices, improved communication protocols	Communication equipment	650+	2	20

In the first stage of this empirical study, the case firms were identified according to the defining criteria (see Chapter 3). The selection process specifically identified R&D active firms that exhibit revealing activities. No commercially sensitive data was elicited during empirical data collection. However, the nature of the phenomenon under investigation meant the participants were sharing firm-specific information relevant to commercial activities, e.g., pending/ongoing innovation projects. Ensuring the anonymity of the firms, projects, participants and any other sensitive data was therefore a prerequisite of the ethics approval. The case firms, projects and the individual participants have therefore been given pseudonyms in the presentation of the narratives.

The case presentations follow a similar structure (Miles et al., 2014; Yin, 2018). Each begins with a background and description of the firm. This is followed by a more detailed description of the innovation projects that contributed data relevant to the revealing activities. Finally, each firm's revealing activities are presented, as guided by the constructs developed for the study's conceptual framework.

4.2 Case firm 1 - EVD

4.2.1 Background of the firm[18]

EVD is a young New Zealand start-up in the construction sector that provides integrated energy saving solutions to residential and commercial buildings. The firm was established in 2013 as a result of an independent construction project carried out by one of its co-founders, Ben, in Auckland, New Zealand. Ben and his life partner built an energy saving building which was not a novel concept at the time. However the knowledge and resources necessary to design a house that integrate building design (architecture) with smart monitoring and energy management systems was scarce.

Ben conducted in-depth research before, during and after the design and build process, resulting in an energy saving home (ZeroH hereafter) with the potential to become 'Net Zero Energy'[19] in the long run. Aware that the extensive research results and accumulated knowledge could inspire many to build energy efficient buildings, Ben and family decided to make all of it publicly available, along with the details of the house, building process and resulting energy data.

> "We did a lot of research. And at that time in our roles, we had access to all the information where we can do the work ourselves and it was relatively easy to get the information and design the house but we realised that a lot of other people who were trying to do it find it very difficult, as they wouldn't get access to all the information they want even to understand if it was possible." (Ben, personal communication, October 19, 2016)

In order to communicate the information effectively, Ben sought his friend Andy's mass communications expertise to build a blog and share his experience with designing and building the house, and the long-term energy savings achieved. Once the blog started attracting views, ZeroH gained the attention of local government authorities and industrial players in the

[18] Information on the firm was sourced from interviews with co-founders Andy and Ben, ZeroH blog, and the EVD website.
[19] Net Zero Energy refers to using equal or less amount of energy than is generated making the net energy consumption zero or less. (World Green Building Council web, accessed on April 22, 2018)

construction sector – both residential and commercial. Identifying the business opportunity to develop zero energy solutions, Ben and Andy formed EVD providing a range of solutions from just developing and installing modulator units to manage energy use to designing energy saving buildings from scratch. The growing success of the ZeroH project, and continuing requests from commercial entities and the public for advice and help on building energy efficient buildings convinced EVD to continue the knowledge sharing activities. It continued the communications campaigns that included workshops, videos and lay publications to share their knowledge and educate the public on the benefits of energy efficient housing, the ZeroH building process, and the performance data gathered from the house in real-time.

As stated in their communications material, the mission of EVD is "to make the lessons and resources from leading-edge building projects available to the world" (EVD, 2016). This mission is supported by four key principles: (1) providing fact-based information, (2) maintaining credibility, (3) contextualised information delivery, and (4) collaborate and create shared value rather than protecting for the firm's benefit[20]. Even though the firm is registered as an energy solutions provider for the construction industry, the company's mission reflects their corporate goal which is geared towards making knowledge available to make a much larger impact in the sector, and potentially for the environment.

> "… A huge part of the company is about disseminating knowledge and teaching people what to do. Which I think is where our fundamental drive of being open and sharing stuff comes from. Because the whole mission of the company is to see improvement in the industry "(Andy, personal communication, October 14, 2016)

> "Sharing stuff, I think is a very important. It's necessary to move forward. Lots of people are doing lots of similar things in the world. It is a connected world. I think, I mean, we are not doing anything absolutely new- lots of people are doing similar things, so starting from scratch seems unnecessary sometimes. If you are able to share the information you are creating to a community of likeminded people, you are helping others who are also helping you to move forward I guess." (Cathy, personal communication, October 25, 2016)

Operating in a shared workspace in the CBD of Auckland, EVD employs five permanent and two to three casual staff who are mostly student interns. The student-interns from local and overseas universities are assigned projects which may be technical (researching and developing algorithms, modifying equipment, etc.) or relate to communications (article writing, research, etc.). The shared space houses approximately ten different firms and several individual users. The workspaces are clustered according to the requirements of each firm, but do not provide

[20] EVD website, accessed April 5, 2018

the privacy afforded by conventional walls or partitions. When asked about this, Andy responded by saying that they are not concerned about privacy, and in fact find the communal style of working at the premises and relaxed boundaries more instrumental than detrimental to knowledge sharing and collaboration.

4.2.2 Innovations and projects of EVD[21]

EVD's main innovation is a product that integrated multiple innovative solutions for energy saving in buildings. Rather than conventional solutions using solar power, smart sensors and monitoring systems which can be installed after the fact, EVD combines the physical and material design of the building with solar energy generation, smart monitoring systems and eco-friendly water management systems. This requires their involvement in the building process from the beginning. ZeroH represents the first application of this technology. While the co-founders believe this technology may exist elsewhere in the world, Ben's research on energy saving buildings confirms that an integrated solution such as that provided by EVD was previously lacking in New Zealand. Furthermore, articles[22] appearing on leading news sites, including a press release by a leading provider of solar energy solutions in New Zealand, describe the energy savings solution provided by EVD as the first of its kind in the country.

The process begins when a client decides to build a sustainable building. EVD prefers to get involved at this point in order to advise clients on how to maximise energy efficiency based on the geography of the site; e.g., its orientation to the sun, land formation, wind direction, surrounding neighbourhood, etc. The building design will depend on these attributes. EVD collaborates with all parties involved in the building process to ensure that required standards are met to maximise savings on energy consumption. Regardless of who provides the energy solutions for the construction, Auckland Council's Auckland Design Manual details the process to follow when building sustainable housing. These guidelines were developed by EVD for Auckland Council at their request, to educate the community on sustainable housing and how to build an energy efficient home.

At the time of the interviews, EVD had only been in existence for three years and therefore had only a handful of projects so far. However, these projects were of reasonable scale and had received recognition. During its three years (at the time of the interviews) of operation, EVD

[21] Information from interviews with the co-founders and researcher's field notes, Auckland Design Manual and various news articles.
[22] Articles accessed October 10, 2017

had completed three zero energy houses including the ZeroH. Although ZeroH has not created any direct revenue for EVD, it is a prime source of business for the company via the shared information and knowledge it has generated over time. Five years after the construction of ZeroH, EVD is now sharing the data and information gathered via its monitoring systems to strengthen their claims for 'net-zero energy' consumption.

Due to the success achieved with ZeroH, as well as the associated publicity created by the EVD team, Auckland Council commissioned them to develop a case study outlining the process for the build and the lessons learnt in the process[23]. The case is included in the Auckland Design Manual.

Another major EVD project is an eco-friendly campsite being built in Queenstown. Apart from providing the energy management design, EVD is also responsible for the educational items, signage and other material that will be on display at the campsite, and on their website, providing information about the various energy saving, eco-friendly solutions and equipment being implemented at the campsite.

4.2.3 Revealing in EVD[24]

EVDs revealing activities can be placed in the extreme revealing quadrant. It shows neither purposive restrictions in access to knowledge nor content. For EVD, the main objective of revealing is ultimately to make an environmental impact by influencing the construction sector to provide sustainable, energy saving buildings, and to accelerate industry growth in this area[25]. When asked if they expect the users of the knowledge they reveal – e.g. potential builders – to hire EVD to implement their energy management systems, Andy emphasised that this is not a concern. Their overarching objective is to influence the construction industry to adapt a sustainable approach to building. They attempt to reveal the knowledge in such a way that potential users can apply it without EVD's intervention as far as possible.

> "… My observation is that building industry often does the same thing; if you did it once, keep doing it. It's easier and low risk to do the same thing. It is hard to even make the smallest changes because that involves learning and more risk and you have to interact with other parties and they have to understand what you are doing and why. So anything you can do to make it easier to make a change. So if someone understands, they did this thing, they would know what to do; it worked; therefore, it's less risky…" (Ben, personal communication, October 19, 2016)

[23] Stuff.co.nz viewed on October 10, 2017.
[24] Information gathered through interviews, news articles and observational field notes.
[25] Interview with Andy on PureAdvantage.org, viewed on September 29, 2017.

However, Andy further elaborated that due to the path dependent nature of the knowledge, reusing and adapting the knowledge may not be easy without consulting EVD.

> "The architects drew up the final [framing] designs and it was beautiful. … The frames they did was very efficient in terms of keeping energy in the building. … They took that design to the company that was building the house and they just did the frames in a different way. … They [framing company] just do things the same way every time. So, from just releasing that framing design and not explaining it to people, you are kind of giving the people the sense that they will be able to achieve this thing, whereas they probably can't. They need the kind of expertise to guide them through it and keep asking that framing/building company all those questions that we had to ask." (Andy, personal communication, October 14, 2016)

Because the aim is to share knowledge as much as possible, the initial question that EVD addresses when deciding to reveal is not, 'Should this be released?', but rather, 'What is the most effective way to share this?'

Even though the mission of EVD is to "make the lessons and resources from leading-edge building projects available to the world" (EVD workshop slides), their revealing practice is not limited to mere project-based knowledge. In fact, knowledge revealing by EVD can be observed on at least two levels: 1) the firm level, and 2) the project level – with the latter providing the most widely shared content. The project level knowledge revealed by EVD includes lessons learnt from the process; information (processed data from the energy sensors and monitoring devices) on energy creation, consumption and management; detailed explanations of how certain implementations work (e.g. the South Island project); and other stories from the projects. They convey this knowledge via both online and print media publications, educational workshops, and demonstration using visual aids.

At the firm level, EVD shares operational information such as payroll, and the experiences and lessons learnt in their journey through the B-Corp[26] certification process. Sharing such information is a way of providing a level of transparency that only a few firms in the world practice, e.g. Buffer.com. EVD follows a similar approach in formulating and sharing internal information. The information in this category includes the salary formulae for each employee type and comparisons of salary scales within the firm, and other expenditure statistics to give some perspective to how their income is utilised. The co-founders feel this practice not only ensures transparency, but also indirectly pressures competitors to maintain fair and reasonable mark-ups. Andy emphasised that the reason for sharing their experiences, especially of the B-

[26] B-Corp, (Benefit Corporation) is the ethical business certification offered to for-profits that is equivalent to the Fairtrade certification offered for coffee.

Corp certification process is to inspire more firms to implement ethical and sustainable business practices.

Furthermore, EVD is highly concerned about effective communication when revealing. For example, EVD insists on a 'hands-on' approach through workshops to ensure that not only explicit knowledge is transferred, but also as much tacit knowledge as possible.

> "… If we really want to make it open, we should be running a workshop with sustainable business network, and work with them to get the right people in the room who would be interested in it and go and do a presentation on it. So it's like, if your idea is IMPACT, you have to do the work to achieve that. You can't just put a blog or on a website and expect that you are going to get the outcome that you need. (Andy, personal communication, October 14, 2016)

One approach EVD follows to ensure effective communication is maintaining consistency across their information gathering systems by using a pre-defined structure. For example, when discussing a potential communications campaign in client meetings, EVD gathers information around six common themes[27]:

1. Vision for the campaign
2. Audience for the campaign
3. Content to be shared
4. Narrative to emphasise
5. Channels to use
6. Implementation – the action plan and the platforms

Collecting information in such a consistent manner allows them to plan, evaluate, and share lessons learnt through that project. A sharing canvas[28] is used across all projects to organise knowledge 'to tell their story'[29] in a way that addresses key areas in a Q/A format. It covers: a) the significance of the project, b) the lessons worth sharing, c) how the lessons are to be shared, and d) the platforms on which to place the stories. As much as possible, EVD uses such defined systems consistently across all operational tasks to make it feasible and effective for staff to work remotely, especially when attached to projects.

The most commonly used method by EVD to reveal knowledge is written articles – both online and print. Developing material for the Auckland Design Manual required careful consolidation, simplification, and de-contextualisation to organise and present the lessons learnt in the ZeroH

[27] Observational field notes taken from a client meeting on October 27, 2016.
[28] Freely available for download under creative commons licence on the EVD website. Accessed August 16, 2017
[29] EVD slide deck for workshops freely available from the EVD website, accessed August 16, 2017

project. EVD follows a similar approach across all article writing. Its co-founders, especially Andy, play a key role in the planning phase of article writing, while Cathy oversees the entire process. Cathy is the in-house design consultant. She is equipped with a background in architecture as well as the training in academic and technical writing received through a postgraduate research qualification. She finds these attributes instrumental in the preparation of different styles of article – visually illustrated articles, website publications, scientific writing, and media releases as well.

However, EVD does not hold all the capabilities required to share knowledge. The company involves subject experts when writing technical articles to ensure accuracy and validate the material; for example, they seek professional landscapers' advice on landscape planning. As another example, during conversations about how to make the performance data from ZeroH available to the public, the need for a cloud-based data management system was raised. EVD did not possess the necessary capability to design, process and manage such a system, especially on a cloud platform where data from multiple sources will potentially be added. EVD therefore had to obtain the expert services of a crowd data platform specialist to implement the system. As a result, EVD not only use an open-source cloud platform but have contributed to the open source community by sharing the code they developed.

Both Andy and Cathy pointed out the importance of 'not knowing too much' as an advantage to understanding, and then producing the writing.

> "For the educational work, we needed a subject matter expert. … them [subject matter experts] being there is really important but then to the storytellers and writers it's important that we know a little bit about the subject but also important that we don't know too much because it has to be filtered through us to be spoken about to somebody that does not know anything. So the most important things are that we can communicate well to somebody that does not understand the subject. (Andy, personal communication, October 14, 2016)

It means they have the ability to understand the 'bigger picture', and also the perspective to view their writing from a learner's point of view.

> "I don't have the technical understanding an Engineer has or I never will… But I have enough knowledge to sort of get the bigger picture. So, I guess the capability is 'not knowing enough' or just knowing enough to understand what the big picture is and being able to write to explain that. And not knowing all the details because if I knew all the details, I probably will try to write down all the details and the complicated stuff." (Cathy, personal communication, October 25, 2016)

Andy further stated that EVD's revealing of project-based knowledge is strategically timed to anticipate situations that may occur within a span of up to at least two years. As such, strategic thinking and planning are required to deliver the message EVD aims to convey, so that the users of the knowledge can take advantage of it when new situations arise.

> "In our educational campaign we are thinking two years ahead, so that we are thinking really carefully about what the vision, in two years, that we want kind of get to. So we are not just writing out from today part of a two years story. And creating that big long-term strategy is, the strategic thinking around the media". (Andy, personal communication, October 14, 2016)

EVD's capability for building on their experience, knowledge and expertise to strategise for the future when planning knowledge sharing activities has created unprecedented vision on top of their knowledge about sustainable buildings.

The biggest challenge EVD encounter when revealing project-level knowledge is obtaining consent from their clients and collaborators, including architects, floor designers, plumbers and frame builders. Because clients tend to be innovators and early adopters, thus fitting the criteria for the first two phases of the innovation adaption cycle, they are usually highly invested in projects and open to sharing the knowledge. The same is not true for other professional collaborators. Their reluctance mainly stems from fear of losing control and rights to IP.

> "… I think people are very scared of giving away their IP and losing control of what makes money for them. (Cathy, personal communication, October 25, 2016)

Sometimes, this can frustrate clients and leads to delays due to their insistence on finding collaborators with a similar outlook towards knowledge sharing[30]. Furthermore, when some knowledge components cannot be included in a revealing attempt, EVD faces challenges to sharing complete and cohesive 'stories' or 'lessons'.

The challenge of simplifying complex technical knowledge so that a wider audience can interpret and apply it in the right way is another major issue for EVD, and one that can prevent EVD from sharing particular knowledge components. However, this is not due to concerns over protecting IP or losing control of the knowledge and expertise, but rather not having the resources or time to figure out the most effective way of communicating the knowledge. In such cases, EVD's decision not to share is not a definitive 'no', but rather a 'may be later' once the best way to communicate the knowledge is figured out.

> "… Most of the time when we decide not to do something it is because we don't have the time or the resources to do it. Not because we don't want to. The only things we decided consciously to keep private are related to our operations. Those things which we eventually will share, but haven't yet - the salaries, income, expenditure, etc., - are more sensitive and you need to do it in a way that doesn't allow for misinterpretation. But in general, we are working towards being more open and making things more public and transparent. (Cathy, personal communication, October 25, 2016)

[30] Field notes taken on October 27, 2016

However, Andy pointed out that for confidentiality reasons, clients' budgets may not be included in the operational information that is shared.

> "I shouldn't be making my clients budgets transparent because that is their business, not mine. Those are like the only places where we stop and think about it." (Andy, personal communication, October 14, 2016)

The main method of revealing used to share knowledge is through publications in openly accessible online and print media. However, EVD believes that only sharing knowledge through such codified methods is insufficient to make an impact. They therefore strive to conduct workshops as well, to explain and present the lessons learnt and provide attendees with the opportunity to quiz them and gather as much information as possible. Each workshop aims to share all information and lessons relevant to a specific project. All material from the workshop is developed using the sharing canvas and the completed canvas is then shared via the EVD website for the public to access. Under creative commons licensing, EVD further shares a guide on how to use and interpret the information presented in the canvas for people who did not attend the workshop but wish to use the material.

EVD separates the knowledge relevant to their business model, specifically the technical knowledge around how the automated system and equipment are developed or implemented in a building, from their operational and educational knowledge. Although EVD is not sharing technical knowledge pertaining to their business model, such as the source code for the automation system, which is one their innovations, neither are they deliberately keeping this information secret, nor taking measures to protect their rights. Nevertheless, where possible and with consent, they still reveal other aspects of their core-product, such as framing, architectural, and sensor designs. Both co-founders believe that each fragment of knowledge is a 'piece of puzzle' which, when put together, provides the 'bigger picture'.

EVD's timing of the release of content alongside significant events is a key part of their strategy to gain as much as attention as possible.

> "…Creating that big long-term strategy is, the strategic thinking around the media… We get awareness around particular subject areas of interest to the public, when we get picked up by journalists. We release a story on rainwater capturing at the end of the summer when everyone is freaking out about water shortages because we know the journalists would pick it up like that (snapping the fingers)." (Andy, personal communication, October 19, 2016)

Therefore, their revealing activities require foresight about future events, seasonal changes and even political situations in order to create effective communications campaigns.

> "We are timing one of our projects to lead into the national elections at the end of next year [2017]. So that the information will get into will be leading up to that." (Andy, personal communication, October 19, 2016).

The most significant and measurable outcome of EVD's revealing activities is the awareness they have managed to create about the feasibility of constructing energy efficient buildings. However, no mechanisms have been set up to measure the actual impact the firm is making.

> "We've been trying to figure out lightly how to do impact reporting which on education stuff is really challenging. Yeah, we don't really have the time or the money to do that. Maybe we should…" (Andy, personal communication, October 19, 2016).

Furthermore, because of the ZeroH blog as well as other communications projects EVD has conducted, several potential clients who share a similar outlook on knowledge sharing have approached EVD about building their energy efficient buildings, as well as sharing the entire process.

> "… The couple [clients of EVD] that is asking how we can do a communication strategy around the small house said 'the only reason we are talking to you is since we know about all the stuff that you made public and gave away and we want you to do the same thing for us' appears like a tangible work basically" (Andy, personal communication, October 19, 2016).

4.2.3.1 Revealing process and activities

EVD is a firm built on the premise of sharing knowledge for the greater good. This is further evidenced by the role-division between the two co-founders – one looks after the technology and the other is dedicated to communications. Due to the importance given to revealing and being open, EVD does not have internal processes for keeping their knowledge secret, or to protect themselves with IP rights that control how information can be reused. On the contrary, they use specific activities in their revealing process to ensure consistent knowledge codification and attract more attention towards the revealed knowledge. This strategy makes the interpretation of the knowledge easier and increases its re-use. They are constantly seeking ways to share knowledge, including operational knowledge. Such activities are presented in Table 4-2.

Table 4-2: Strategic actions in the revealing process

Action	Purpose	Evidence
Preparing a long-term strategic plan	To envision the ultimate goal of a 'communication campaign'	"So, like in our educational campaign we are thinking two years ahead, so that we are thinking really carefully about what the vision in two years, that we want kind of get to. So we are not just writing out from today part of a two years story. And creating that big long-term strategy is, the strategic thinking around the media." (Andy, personal communication, October 19, 2016)

Action	Purpose	Evidence
Consistency in knowledge composition	Identify and arrange knowledge relevant to each project in a consistent manner for easy retrieval and sharing	From the illustration for EVD's approach to communication of knowledge: "Discovery - Workshops with the building's owners, users, managers and designers to understand opportunities and principles of communication." "Narrative - Long-term communications narrative established. Definition of key messages and creation of construction image shot list." (EVD workshop material, viewed August 16, 2017)
Systematic planning of revealing activities	To ensure that a strategic plan is made for effective communication	From the illustration for EVD's approach to communication of knowledge: "Plan - Definition of communication vision, objectives, audiences, channels. Definition of control & monitoring objectives, high-level data model. (EVD workshop material, viewed August 16, 2017) "Andy presented the six stages of information required for the campaign. He used documents from previous projects to elaborate the level of information required to finalise each point. These points are in a sequence that is inter-related." (Field notes of client meeting, October 26, 2016) Campaign planning vision board: "Sharing canvas 1. What makes your project unique? 2. What have you learned that could help others? 3. How should you tell your story? 4. How can you get it out there?" (from EVD website, viewed on August 16, 2017)
Timing revealing activities based on real world events	To ensure the knowledge receives maximum attention	"We scheduled our relevant content to releases on the same months when the public cared about the solar, or water shortages, cold and damp homes so that the information we put out is more likely to be picked up by the media and the public." "With the Ben's house, we timed our publications and media coverage. We released content… on the water systems, we timed the content to go into the water industry magazines two weeks before the media coverage to get the awareness." "And creating that big long-term strategy is, the strategic thinking around the media and …. Like we have awareness around particular subjects are of interest to the public when we get picked up by journalists when we release a story on rainwater capture at the end of the summer when everyone is freaking out about water shortages because we know the journalists would pick it up like that (snapping the fingers)." (Andy, personal communication, October 19, 2016)

Action	Purpose	Evidence
		From the illustration for EVD's approach to communication of knowledge: "Narrative - Long-term communications narrative established. Definition of key messages and creation of construction image shot list." (EVD workshop material, viewed August 16, 2017)
Targeting potential users of knowledge	To ensure that relevant knowledge reaches relevant users for high potentiality in re-use	"But if we really want to make it open, we should be running a workshop with sustainable business network, and work with them to get the right people in the room who would be interested in it and go and do a presentation on it. So it's like, if your idea is IMPACT, you have to do the work to achieve that. You can't just put a blog or on a website and expect that you are going to get the outcome that you need." (Andy, personal communication, October 19, 2016)
Knowledge validation	To ensure that revealed knowledge is readily re-useable	"…there was a little bit of a discussion around when do we make it open, because, it was not about protecting the IP but was about more if it is useful to anybody when it's got heaps of bugs and we don't have any documentation, and we don't even know if it's working, I should wait until the point it works and then make it available to the community that uses that cloud platform. We were pretty sure we decided that we will keep it private until we are done, and it is ready and then make it public." (Andy, personal communication, October 19, 2016)

EVD puts in place specific procedures from the beginning of the revealing process to ensure that knowledge is systematically captured, and that activities are strategically planned and can be monitored for impact. These procedures further ensure that the same process is replicated across all innovation projects to ensure consistency. The process begins with establishing a long-term plan for each 'communications campaign', as members of EVD call revealing activities. This is linked with the systematic planning approach illustrated below (Field notes from client meeting, October 26, 2016).

1. Vision statement – the main aim of the campaign. This influences the entire campaign.
2. Audience –who are the intended recipients?
3. Content – what type of content is required to put forward? How will it be collected, prepared? Who will be responsible? How deep the content needs to be.
4. Narrative – Andy related this to the context that J [client] mentioned. How to make sense out of the content? Time based – when should the content be deployed? Andy showed examples from the SI project. Recommended using small chunks of content rather than big ones.

5. Channels – media for communication.
6. Implementation – platforms.

Information for each of the six items is collated at the beginning to develop a suitable 'communications campaign' using a combination of multiple revealing mechanisms. The planning session further includes preparation of the sharing canvas. The aim of the sharing canvas is to derive answers to four specific questions[31];

1. What makes your project unique?
2. What have you learned that could help others?
3. How should you tell your story?
4. How can you get it out there?"

The canvas extracts the necessary information to plan a 'communications campaign' based around a building project. Canvases serve two purposes. They 1) make the planning process easier for EVD and clients by extracting and modularising the most important knowledge components from a large base of knowledge into meaningful, manageable parts in a consistent manner, and 2) make the re-use process easier for potential users due to the consistent arrangement of knowledge across various projects. The sharing canvas template is shared via the EVD website under a creative commons license.

Once the campaigns have been planned, EVD takes specific actions to ensure the knowledge reaches a wider audience beyond its potential users. This is important because EVD is striving to create awareness and educate a wider segment of society about environmental sustainability, as well as aiming for increased reusability of their knowledge. The use of milestones such as changes of season, political events, targeting specific journals or local authority institutions such as councils with information, or making presentations at conferences dedicated to construction, the environment, etc., are among the tactics EVD has used to spread awareness.

Finally, EVD takes seriously the potential pitfalls of sharing knowledge that is then used in a different context.

> "… Especially in construction, it is not something that you just will be able to kind of pick up and drop them somewhere else. I guess they need to be designed for the site. …" (Andy, personal communication, October 14, 2016).

[31] From EVD website, viewed August 16, 2017.

Accordingly, they feel the need to evaluate, test and validate the knowledge they share. As Andy pointed out, sometimes this validation process takes time and the sharing process is delayed, but it is nevertheless an important step in the revealing process that cannot be compromised.

4.3 Case firm 2 – LMO

4.3.1 Background of the firm[32]

LMO was founded in 2012 by a group of activists, including Dan – one of the co-founders, who recognised the need for a decentralised decision-making platform. The founder members' involvement in the Occupy Wellington campaign in 2011 made them aware of how organising in the right way can create impact on a larger scale. The software LMO was created with the central aim of providing a virtual platform for people, either in formal organisational environments or informal community-based environments, to make decisions "without hierarchy, without authority, and without a boss" (Dan, personal communication, September 16, 2016). Six co-founders were involved in forming the company. Three were activists for social change and the other three were part of a New Zealand (NZ) based network of Social Enterprise enthusiasts (SEN), and well versed in the operational aspects of social enterprises and a collaborative work style. The support from SEN was vital to transforming LMO into a sustainable venture, "rather than a random, enthusiastic hobby" (Dan, personal communication, September 16, 2016).

From its beginnings, LMO's founders held in common a set of "explicit ethics" relating to activism (Dan, personal communication, September 16, 2016). Even though they came from different fields, the founders had a shared commitment to "maximise positive social impact" (Dan, personal communication, September 16, 2016). The core values of LMO are bounded by being an independent and neutral cooperative social enterprise. They further value being an open source collaboration – adaptive, reflexive, user driven and transparent[33]. These values and ethics have guided the way the firm raises funds, and how they set up their business model, operational style and organisational structure. One of the most challenging problems LMO has faced is financing the firm. Since their sole product, the LMO software is not for sale but

[32] Information from interviews, company website and news articles.
[33] Information from the co-operative handbook of LMO.

available for free, LMO has had to look for financing options that do not compromise their ethical standards.

> "We started by rejecting everything and then designing what we think is the ideal and then we actually do the research and connect our idea with what is actually realistic and find some happy medium." (Dan, personal communication, September 16, 2016)

LMO has gone through four funding cycles since its inception. Initially, funding was raised in 2013 from 'friends and family' in the form of social impact loans. The second round was a crowd funding campaign, where around 1700 people worldwide contributed to raising $130,000. The third round consisted of philanthropic donations sourced from capable individuals and organisations in NZ. Finally, about $600,000 was raised through the issue of redeemable preference shares[34]. At the time of data gathering, LMO was preparing for another release of redeemable shares.

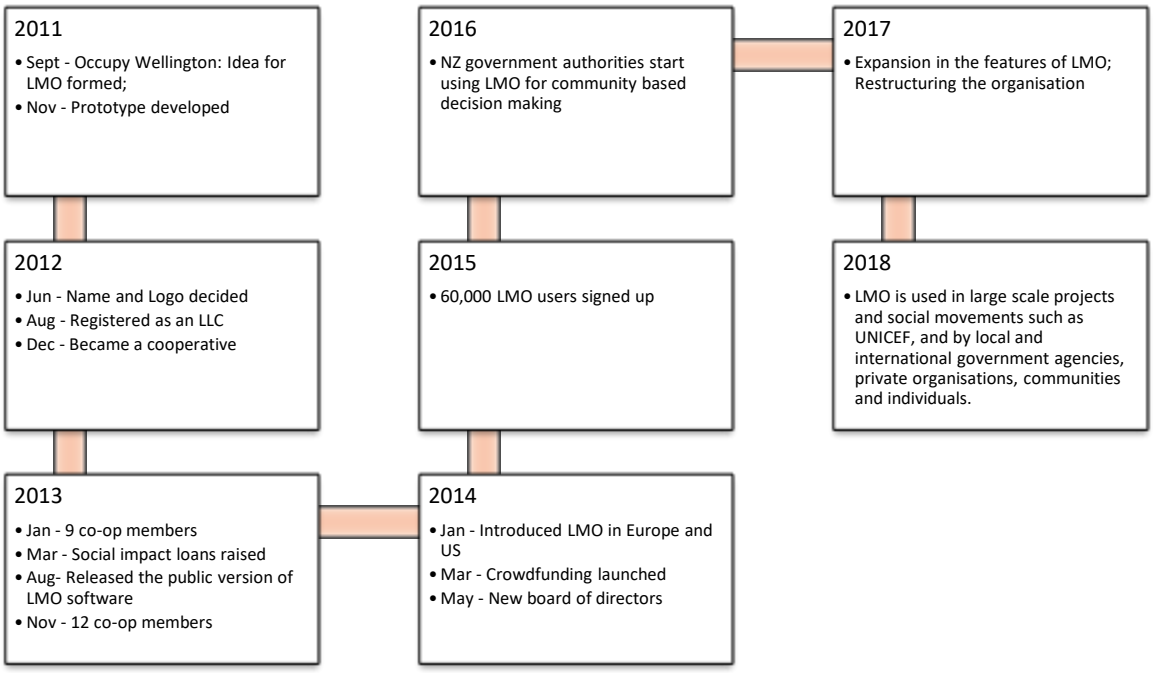

Figure 4-1- Milestones of LMO. Information sourced from LMO blog and publicly available timeline presentation

LMO is registered as a co-operative and operates under the co-operative laws of NZ. However, Greg, a director and the business development manager, stated that LMO's co-operative operational style is unique to the firm. In 2016, LMO was owned by 12 'worker-members' who

[34] Redeemable preference shares are a type of shares with a fixed maturity date and which can be redeemed by the issuer for cash at maturity. These shares do not have ownership attached to them, nor are dividends paid.

were employees as well as shareholders of the firm. They appointed the board of directors. Due to investment in the company from external parties, it was vital to establish a board of directors to oversee operational aspects and the financial performance of the firm[35]. At least 40% of the LMO directors must be co-op members. Currently, LMO has five directors and more than ten 'worker-members'.

Initially, LMO was located at the SEN offices in central NZ. It later moved to a shared workspace with a number of other firms and individuals. Since 2017, it has been based in a dedicated workspace provided by a political party that has a manifesto to create environmental impact.

4.3.2 Innovations and projects of LMO[36]

The study considered LMO's innovations in product and organisational management. LMO's core product is their eponymous, innovative web-based software solution, which enables groups of people to make decisions without having to be in the same room. Their aim was to provide a platform to enable decentralised decision making for formal and informal organisations. Unlike other similar software that uses a simple majority voting system to make decisions, LMO is user driven, whereby the software allows its users to define how a decision is made. The program includes features for commenting, critiquing and voting for 'proposals', or even to 'block' proposals from moving forward. There is a free version of the software available for small groups to use. The pay versions include a package of features such as more users and grouping options, and other relevant software integrations and import/export facilities for data. Subsidised packages are offered for non-profits, and unfunded groups. This product is widely used within the activist community around the globe[37].

Apart from the web-based software, LMO offers the LMO application and related data hosting services to users in a cloud-based environment – a concept generally known as 'software as a service'[38] (Greg, personal communication, September 16, 2016). It also provides a web-based application of LMO to organisations for hosting and maintaining their data on a server.

[35] Information from the LMO Co-operative handbook and interview with Greg, Director and Coordinator.
[36] Information from the LMO blog, website and LMO Co-operative handbook.
[37] Information from third party websites such as akina.org.nz and g0v.news.
[38] More information can be found at www.techopedia.com/definition/155/software-as-a-service-saas

LMO views their organisational management structure[39] as an innovation (figure 4-2). With a co-operative management style and abiding by their core values and principles, LMO has adopted a flat "boss-less", decentralised organisational structure that is evolving over time. The cooperative management style allows employees to be owners or 'worker-members' of the firm. In the absence of senior management to oversee the day-to-day operations, LMO appoints 'coordinators' (Eilene, personal communication, September 16, 2016). This position is equivalent to senior management in other organisations (LMO Co-operative handbook, viewed September 18, 2016). At any given time, there are two 'coordinators' managing operations.

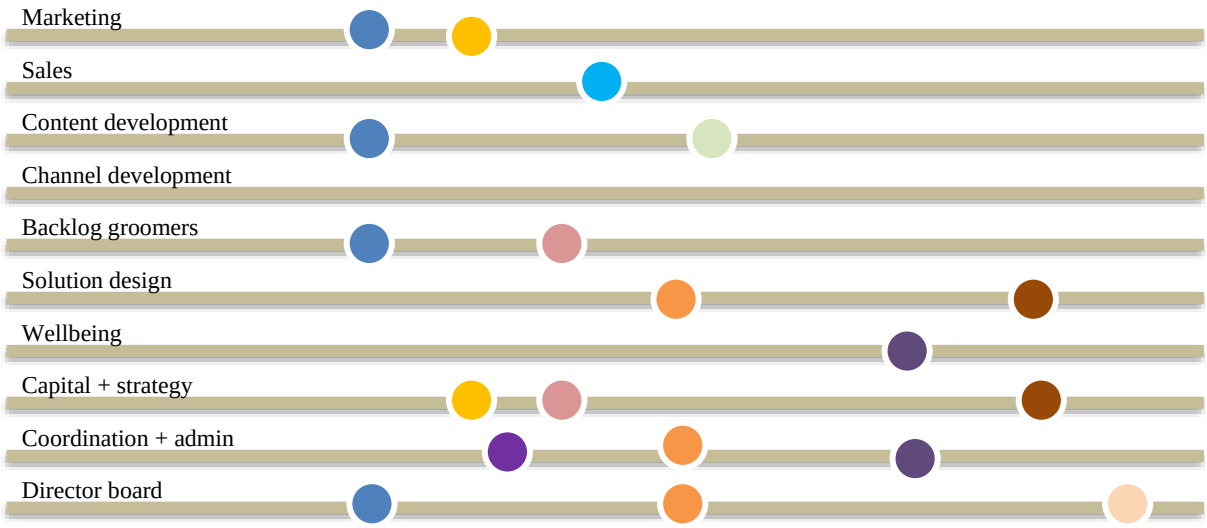

Figure 4-2: Organisational structure from the LMO website. Nodes represent worker-members. The positions of nodes are indicative only, and not an accurate representation of the actual roles held by members.

Furthermore, LMO has implemented a 'stewarding' system to look after the wellbeing of their employees (Eilene, personal communication, September 16, 2016). Every employee has a 'steward' within the firm who acts as a 'mentor, guide or a sounding board'. LMO believes that 'looking after' their members are vital to functioning as a team. Every day, LMO members gather together in a morning 'stand-up' session, where each employee shares updates on their work as well as their general wellbeing[40]. The members respond to three general stand-up session questions[41]: (a) What did you do yesterday?; (b) What will you do today?; and (c) Do you have any blockers (challenges), or need support with anything? LMO has added a fourth question to the sessions: (d) What will you do for your wellbeing today and how can we help

[39] Information from the interviews and LMO Co-operative handbook
[40] Observational field notes.
[41] Stand-up meetings are the norm in an agile software development setting, and generally these three questions are addressed by each staff member.

you? [42] The members of LMO believe that creating a 'caring organisation' through 'talking, listening, and supporting' is important to providing a space that upholds a sharing culture[43].

4.3.3 Revealing in LMO

The driving factor behind LMO's motivation to reveal and be open is their greater goal of creating social change by allowing people to organise in a decentralised manner and make decisions together effectively without the need for authority. They also believe in ethical business standards. These standards are built on the core values defined for the company (Table 4-4), which LMO aims to integrate into all aspects of its business.

Table 4-3: Core-values of LMO. Extracted from the LMO Co-operative handbook

Cooperative social enterprise	LMO is a social enterprise collectively owned by the people forming it. Unlike a traditional profit maximising company, revenue is not an end in itself, but a means towards achieving a core social purpose. A worker-owned cooperative structure is a powerful way to live our values of collaboration and collective ownership.
Independent and neutral	LMO is committed to remaining independent so it can provide a neutral place for any group to come together.
Open-source collaboration	LMO aims to develop open-source tools that make collaboration accessible to everyone.
Adaptive, reflexive, user-driven	LMO aims to develop tools which are iterative, self-reflexive and adaptive, driven by the collective wisdom of the user community.
Transparency	The LMO Co-operative will be surrounded by a valued community of users and contributors. This community must be confident that the LMO Co-operative is doing what it says it is. We are committed to high standards for sharing information.

In a 2016 conference presentation, Ally, one of the co-founders of LMO stated, "What you are internally, defines your impact externally." (OSOS conference, 2016). The firm applies this dictum by trying to be open not only in terms of its products, but also throughout its development and management processes. Dan explained that it was a natural decision to become open in such a manner.

> "I think it's not like, that we sit back with a whiteboard with pros and cons of open and closed, it's [openness] just a reflection of our values and our culture." (Dan, personal communication, September 16, 2016)

The continuing background influence of SEN has enabled the worker-members of LMO to develop the skills required to share their knowledge. Even though all members of the LMO

[42] Clarification from Eilene in response to the case feedback request. Received on October 12, 2018
[43] A blog post written by Dan to a third-party blog on creating caring organisations.

software development team are familiar with the practice of sharing source code, some assistance was received from SEN who shared knowledge around their management style to help LMO develop their business model.

The firm's revenue model is the most challenging aspect to being open and upholding the core-values of the firm. Greg described the tension that surfaces between their dual roles as a social enterprise and a software firm with high potential for growth when raising capital. As a software firm, LMO can potentially attract investment from venture capitalists, but this could compromise the firm's core values of being independent and a cooperative. However, the sales and customer service coordinator, Ivan, and an LMO director, Joanna, both described how lack of funding ipso facto affects openness to some degree as well.

> "I guess one thing [challenge] is, because we are still poor, we are less open and participatory than we like to be. In the past we used to have a public roadmap, you could see what we plan to do in the next 3-6 months in the product development. It takes quite a lot of work to keep that going. But now, that stuff is inaccessible and hidden away. It'd be nice to be more transparent." (Ivan, personal communication, September 16, 2016)

> "The biggest barrier by far is being under resourced because if we had more resources we would make more proactive commitment to sharing what we do now as opposed to, you know, minimal viable approach." (Joanna, personal communication, March 14, 2017)

Furthermore, providing a free version of the software to encourage its use is important to achieving their goal of making a societal impact. Therefore, the firm has to rely on donations and funding from sources that do not compromise the overall "ethos" of the firm.

LMO's main method of revealing is through making the source code for their software open source. Apart from protecting the LMO logo and name as trademarks, the code is available for anyone to adapt, improve or copy. Ivan, one of the developers of LMO, stated that the software has already been copied by a foreign firm and presented under a different name in their native language. However, the foreign firm has acknowledged the original LMO software[44].

This mention earned LMO significant attention they 'could not understand' at first (Ivan, personal communication, September 16, 2016).

The development process for their product, as well as milestones in the establishment of the company, are shared publicly via a live timeline. The timeline presents and explains each

[44] From the foreign firm's website viewed on 20 September 2016.

organisational milestone, including collaborative steps and key decisions, and when and how collaborators joined the project.

LMO still continues to engage users in development decisions about the software. The LMO community is a public group hosted on the LMO software. Any interested party can join the group to make suggestions and comments, or even propose changes to the software. This is an instance of LMO using their own product for decentralised decision making.

> "Anyone can join the LMO community group. It says about where the product is going, we have open conversations with the members of groups, and say, 'we are going to do this functionality' and what does people think about it? So we get feedback from our users, and we build the software with them. So people are included in our decisions." (Fiona, personal communication, September 16, 2016)

Fiona believes that such wide engagement in the growth and the development process not only ensures a product that users feel is 'right for them', but also maintains transparency.

Additionally, they provide support and learning via a special online 'manual-type' platform aimed at engaging users of their products in problem solving, as well as capturing new ideas for products, or features to add to the existing product. Information including how the software works, and how to customise it according to specific user needs, is provided on the platform. In addition, the online handbook also features stories on how LMO software has been used in different contexts to achieve collaborative decisions and organising. Since the revenue model used by LMO is not dependent on the core knowledge underpinning their product, a significant amount of knowledge revealing takes place through this platform. The platform even provides the necessary knowledge for users to develop their own LMO adaptations.

All knowledge relevant to the open management style of LMO is published via an open source e-book. It provides detailed descriptions of all aspects of the management of a traditional co-operative, including governance, operational aspects, organisational structure, and various roles, as well as the company's governing principles. Additionally, the LMO 'Co-operative handbook' as the firm prefers to call it, includes management practices unique to LMO, as adapted from the agile software development process, including the stewardship programme and stand-up style of meetings. The book as well as all the source code relevant to their product are published and shared by LMO under a creative commons license through GitHub[45].

> "There is the handbook of the organisation. All the structure and how it works is open source as well. It's online. So that everyone can grab it and start using it. For me, part of who we are is also how we

[45] An online software platform that manages and distributes open source software products: https://github.com/

> work. How we learning to work in a different way so that we can share and all else can do it, replicate it. So that is open." (Fiona, personal communication, September 16, 2016)

Further, LMO openly shares the lessons learnt throughout their journey at conferences and workshops.

> "We are really open about the fact that we are still learning to be in this space. We are very open to sharing our learning journey." (Eilene, personal communication, September 16, 2016)

Members are open to approaches by anyone with questions or concerns about their products, as well as their management style. Eilene feels that is also part of being open.

> "The accessibility to the team when people have questions. It is also openness, but it is the fact that we are making time to share. It is very intentional decision on our part, to share the information and our time with people who have questions. Take yourself, for example. We are living by what we are proposing." (Eilene, personal communication, September 16, 2016)

From time to time, LMO conducts free workshops[46], to allow users and any interested parties to visit the LMO office and learn about LMO software. Such occasions are used to demonstrate how to effectively use the software for decision making, and are also opportunities for LMO to receive feedback, suggestions and critique about the application of the software in different contexts.

For reasons of confidentiality, the only information that LMO does not share publicly pertains to the personal information of donors and investors.

> "Openness is making a lot of the work that we do accessible without causing a problem for safety of certain type of information." … "The openness is to a degree to how far one would go. But if you look at the LMO handbook, a lot of information does go out. It is important to strike a balance between sharing information to help people and keeping confidences and people safe." (Greg, personal communication, September 16, 2016)

LMO feels it has been successful in achieving its aim through being open. Because the LMO software is available free to small groups, it is used worldwide by communities and activist groups to make quick and effective decisions. The software is also used by government agencies, both globally and within NZ and by larger non-profit organisations for community-based decision making. LMO is able to monitor the impact it makes via web analytics such as unique visits to the 'handbook' and online manual, unique number of downloads, usage data for the software, etc. In fact, Ivan shares all updates on impact factors and sales made each day on an open notice board in the LMO office.

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[46] Observational field notes.

4.3.3.1 Revealing process and activities

LMO is driven by ideals around activism and the open source movement. Members of the firm strongly believe in the need for openness, transparency and collaboration to create societal impact. The company's products as well as the management style are evidence of a strong commitment to the ethics underlying the organisation's value system. As outlined in the company's handbook, and confirmed in the interviews with worker-members, transparency, collaboration and openness are at the core in decision making on all organisational aspects, including their innovations, management style and even the business model. Furthermore, the aim of making a societal impact through educating and enabling individuals, communities and organisations to embrace a collaborative, caring and transparent work style is at the forefront of all revealing activities. As the co-founders pointed out, openness in the organisation is a natural occurrence, rather than an outcome of a premeditated course of action.

A shared ideology and belief in a collaborative and open work style dictates the revealing decisions of the firm. The question of 'whether something should be kept a secret' has never been raised, even in meetings where 'content review' takes place. From the beginning, the company established that everything they create will and should be shared openly. The interview with the co-founder Dan made it clear that the "ethics of the firm are non-negotiable". LMO designs all revealing activities around the ethics and values outlined in the handbook.

LMO's revealing process is based on the desire to create societal impact through encouraging a collaborative work style and collective decision making. Their product and management styles embody their commitment to the cause. Hence, the overarching aim of revealing activities at LMO is to enhance the reach and reusability of the knowledge they share openly, and strategic actions taken by LMO when revealing are focused on achieving this goal. Table 4-5 outlines the actions taken by LMO, as well as corresponding evidence from various sources.

Table 4-4: Strategic actions used by LMO for revealing

Action	Purpose	Evidence
Multilingual presentations	To maximise the reach of the knowledge and thereby increase reusability	"I am in charge of the translation as well. So LMO is being translated into 33 different languages. And it is mainly done by volunteers. I do the translation into Spanish and do support for the Spanish users. I have that main role and I also do little bits and pieces." (Fiona, personal communication, September 16, 2018)

Action	Purpose	Evidence
Maintain context of knowledge	To ensure that users understand the knowledge as it is intended to be understood	"So context is really important when you are working open. Making sure that if you are going to be working transparently that you are really working hard to make sure that the people who are consuming your information have the context they need. So transparency has a cost; it is something that we really have to work on. So it takes a lot of our time. If we are going to be open, we actually need to work on the façade of openness and what it is – the handbook and that kind of stuff." (Isaac, personal communication, September 16, 2016)
Using a combination of revealing media	To ensure that both explicit and as much tacit knowledge as possible are shared	"There is the handbook of the organisation. All the structure and how it works is open source as well. It's online. So that everyone can grab it and start using it." "Anyone can join the LMO community group. It talks about where the product is going, we have open conversations with the members of groups, and say, 'we are going to do this functionality' and what do people think about it? So we get feedback from our users, and we build the software with them. So people are included in our decisions." (Fiona, personal communication, September 16, 2016) "It is also down to our participation in various conferences, and the information that we share and talk about." "We are very open to sharing our learning journey and it's all in the handbook basically. Pretty accessible to anybody." "The accessibility to the team when people have questions. It is also openness, but it is the fact that we are making time to share. It is a very intentional decision on our part, to share the information and our time with people who have questions." (Eileen, personal communication, September 16, 2016) "I do software design and storytelling - love doing it, and yeah, giving talks." (Dan, personal communication, September 16, 2016) "We have a blog. Also we collaborate with journalists who sometimes write articles about us, and even twitter. I'd say those are the main ways that we are getting the word out. We are currently doing some research which you are probably aware of on the stories of our users. So we are doing more video about that, sort of collecting a database of user stories that we can better understand and also share the impact of LMO so those practices we would also share. So the video would be another medium." (Joanna, personal communication, March 14, 2017).

Action	Purpose	Evidence
Engaging with the users of the knowledge	To involve potential users of knowledge in the creation process as well as receive feedback and new product ideas	"Anyone can join the LMO community group. It talks about where the product is going, we have open conversations with the members of groups, and say, 'we are going to do this functionality' and what does people think about it? So we get feedback from our users, and we build the software with them. So people are included in our decisions." (Fiona, personal communication, September 16, 2018)
Using advanced technology to deliver knowledge effectively to users	To deliver knowledge instantly and target it to the audience as they seek it	"I think our goal would be to ask people to use the tool. So we can use artificial intelligence, you know bots for instance that people are gaining more mastery about what we know about how people facilitate well [sic]. We have a lot of resources available on the site, but the people sort of blunder through and probably nine out of ten people don't really look at those resources and they definitely don't look at them as they are working. But what I think what bots do is they integrate them in just in time so if they are muddling through and they are not getting let's say people to respond we can share oh, here are some knowledge we have about ways to engage your group for instance." "We are also considering developing a just in time coaching network, so you know that would be another way to do knowledge sharing when people get stuck." (Joanna, personal communication, March 14, 2018)
Collective decision making on aspects of revealing	To ensure effective communication of knowledge and ensure the values of the firm are met	"During sprints, members present work that they need suggestions about, or feedback on content relevant to the software or the two handbooks. The segment is called 'content review'. The decisions about how to proceed with a publication were made on the spot involving everyone present. The presenter would ask 'what do you think about this?' and the members would present their ideas, suggestions, and their opinions on the matter." (Extracted from field notes, September 16, 2018).

The demand for multilingual presentations confirms there is a wider audience for the knowledge around the world. The translations are carried out at the source of the knowledge to ensure the knowledge is received as it is intended to be received, without compromising the quality or the message. Members of LMO also believe that the context around the knowledge is important to conveying the message, to help users of the knowledge to apply it in appropriate situations. For example, the management style is based on an open structure and there is no designated 'boss' to provide authority and take decisions on behalf of others. Taken out of context, it may appear that decisions are made randomly, without a rationale or careful thought. Instead, decisions are made collaboratively through discussion and critique, whereby all members participate and arrive at a decision they all agree on.

> "Our version being open is that we are a cooperatively owned company. I've got a member share. That means I've got equal stake holding to all the other members. The benefits of that aren't immediately apparent. In fact it is more difficult because the usual hammer for situation is to say I've got a majority, so I make the decision which seems like a really useful situation. In the past a lot of people's experience would be 'oh it was so great, that person was able to sort out the situation because otherwise it would have been a deadlock'. But not when you have a group of people who are reliant around shared mission, over profit and their own personal interest." (Isaac, personal communication, September 16, 2016)

The use of multiple methods and media allows the members to communicate both explicit and tacit knowledge. Blogs, open source codes and handbooks, talks, and online discussion forums allow explicit knowledge to be shared, while the workshops support tacit knowledge sharing by demonstrating applications of the knowledge. Using advanced technology such as artificial intelligence (still in the experimental phase) adds benefit by providing instant, targeted, 'just-in-time' delivery of knowledge to users when needed. Engaging with users for feedback and innovation further ensures that LMO is presenting knowledge relevant to the users. All these actions contribute to increasing knowledge reach to a wider user base and enhancing reusability. Finally, the collective decision-making style for all aspects, including revealing activities within the firm, shows that the firm is not just applying Linus's law[47] to software development. The 'content review' segments of meetings are dedicated to defining the best communication strategies for the knowledge components. If a decision is made not to proceed with a knowledge sharing activity, it is because the knowledge is not ready yet, rather than any intention to protect themselves[48].

4.4 Case firm 3 – SMX

4.4.1 Background of the firm[49]

Established in the early 1990s, SMX is one of the leading applied research institutes in New Zealand (NZ). It is governed as well as partially funded (approx. 12% of total expenditure)[50] by the NZ government. It currently employees more than 400 people across three major scientific platforms: human and environmental health, and forensic science. Although there are managerial boundaries established for each division, the operational demarcations between the

[47] Linus's law stipulates that "given enough eyeballs, all bugs are shallow" which means, problems are easily resolved when approached collectively. – Eric Raymond, in his book, The cathedral and the bazar, 1999.
[48] From field notes taken at the sprint meeting on September 16, 2016.
[49] Information from interviews, company web and news articles.
[50] Interviews and from annual reports.

three platforms are blurry due to the inter-organisational collaborations SMX engages in as part of its research and development activities.

The institute aims to achieve three major goals: 1) conduct quality and valid research; 2) do this for the benefit of NZ, and 3) be sustainable. As a research institute, achieving the third goal has proven comparatively difficult. However, a recent annual report of the institute shows that more than 75% of SMX's total revenue comes from international and NZ based commercial activities, especially in the forensic science division. Due to the considerable scope of its commercial activities, SMX has established a commercial and business development team to oversee the sizable commercial activities of the institute, particularly the forensic science division. However, as emphasised by the commercial team, because the amount of funding received from government and other funding agencies is insufficient to carry on effective R&D and remain sustainable, SMX looks for commercialisation opportunities wherever possible to boost their research output.

As well as conducting applied research in the fields of health, the environment and forensic science, SMX also provides products and services relevant to these three areas. The main service provided by SMX is their expertise and laboratory facilities for identifying narcotics, pathogens, and testing forensic samples, etc. Experts at SMX provide research and training facilities for testing samples and interpreting results, as well as assistance in conducting forensic investigations. The clientele of SMX includes a range of public and private entities from government and government authorities such as the police and other enforcement agencies, environmental protection agencies, other research facilities, universities, and private investigation agencies. Through their expertise and high-quality research, SMX has been instrumental in enhancing the quality of criminal investigations, biosecurity, food and water quality, as well as the general wellbeing of NZ citizens[51].

The largest proportion of R&D activity with a commercial intent is centred in the forensic science division of SMX. The competitive advantage of SMX Forensics lies in their expertise in processing and analysing evidence from forensic environments. After conducting laboratory investigations for over 20 years, SMX has established strict benchmark standards for collecting, reporting and transporting evidence samples to avoid decontamination. SMX Forensics also has the relevant ISO (International Organization for Standardization)

[51] From the SMX Annual report 2017.

accreditation with regard to the quality assurance processes required to conduct forensic investigations.

4.4.2 Innovations and projects of SMX[52]

SMX's innovations falls mainly into product and process categories. As explained in the following sections SMX develops software based products for forensic analyses as well as novel processes of analysing forensic evidence.

Over the years, SMX has developed a number of scientific discoveries pertaining to the fields it is involved in, as well as introducing commercial products that are used both in NZ and worldwide. A summary of the innovations and projects presented here that indicated revealing activities (Table 4-5). Software developed by forensic scientists at SMX in collaboration with an Australian forensic agency is seen as the most successful innovation so far.

Table 4-5: SMX projects with a revealing component

Project	Innovation process	Purpose	Knowledge outflow from SMX	Outcome
DIP	Collaboration with an overseas forensic agency	To develop an analytical process to retrieve individual DNA data from a mixed DNA sample with high accuracy	Expertise and experience in DNA analysis methods, techniques. Provided clear insight to the problem at hand for developing the solution.	The software DIP which is used in NZ and worldwide for DNA analysis. Now managed via a newly formed subsidiary firm of SMX.
RNA (ongoing)	Collaboration with an RNA analysis equipment manufacturer	To develop an analysis process to retrieve RNA information from forensic samples	Problem related information accumulated through experience in investigations, unsolved cases, etc.	Potentially a product similar to DIP
TDV	Collaboration with a digital animations firm	To produce a virtual-reality like visualisation of a crime scene that is interactive	Processes and standards for criminal investigations	Patent obtained but has not been commercialised. Consultancy provided to use the technology for forensic and other applications.
Narc	Collaboration with a local university	To develop an on-site drug detection system for specific drugs	Lessons learnt from past drug detection analyses applied to current processes for analysis	Potentially a portable drug detection system targeted at specific drugs that cannot currently be tested on site
Foreign Gov.	Collaboration with a foreign government department	To learn CBRNE detection and management	DNA related science and technology	Data relevant to application of DNA technology in human trafficking settings; knowledge base to prepare for CBRNE related threats.

[52] Information from interviews, SMX website and news sites

Mike, the R&D manager explained that the software – DIP[53] - is instrumental in "untangling the results of a mixed DNA samples" (Mike, personal communication, August 09, 2017). This has solved a problem shared by forensic investigators worldwide – accurately identifying and interpreting DNA samples retrieved from crime scenes. Previously, when a sample contained DNA from multiple contributors there was no means of identifying the individuals involved. DIP has enabled investigators to address this issue with high accuracy. The product has become so successful since its development that a subsidiary firm of SMX was established in early 2018 to manage commercial activities, including servicing and maintenance of the DIP software, training people in its correct use for accurate results, as well as providing consultancy services around DNA analysis.

Furthermore, SMX has established a collaborative partnership with a US based genetics research firm with expertise in DNA and RNA[54] analysis equipment and technologies to develop a solution for RNA analysis that may give them a commercial advantage. Much like the case of DIP, once the solution is developed, it will be evaluated in terms of the requirements of forensic or other applications to identify potential commercialisation opportunities. At the time of data collection, the project was at an early stage, with possibilities still being explored collaboratively by the two groups. While SMX brings vast knowledge and expertise on RNA analysis accumulated over the years, the partner firm can provide the necessary equipment and technology to develop the solution. SMX hopes to act as a user-innovator, and work with the US manufacturing firm to develop customised solutions for RNA analysis.

In another collaboration with a digital animation lab in NZ, SMX developed a 3D visualisation product called TDV[55] to virtually represent a walk-through of a crime scene. The output is similar to modern virtual reality computer games, with life-like imagery and persona. The intention is to enable interested parties to virtually explore a crime scene without having to be physically present at the location. For example, TDV could be used in court to provide interactive visualisation of a crime scene for the jury. The digital animation lab had the necessary knowledge to develop software to accept input from crime scenes, such as laser

[53] A pseudo-acronym.
[54] DNA reveals the genetic code of a person – age, gender, health, etc., whereas RNA reveals the tissue type – saliva, blood, brain tissue, etc.
[55] A pseudo-acronym

scanning, 3D images, videos, etc., and then visualise a crime scene. However, although patents were filed, and the necessary validation obtained through peer-review publications, the product did not proceed beyond the prototyping phase and onto commercialisation. Mike felt that SMX's inexperience in the software development field was a potential barrier to commercialisation in this instance.

> "I guess one of the possible reasons is that the 3D visualisation area is very rapidly moving and there are some very big players involved. I guess it is one thing to create a product concept that looks good and filled that gap but another thing to get that to market quick enough that you can capture a section of the consumer base. Plus it was quite a different thing to SMX to get into. We are not really a visualisation or a software company." (Mike, personal communication, August 09, 2017)

While TDV has not become a commercial product, nevertheless SMX is currently using virtual reality and 3D visualisation for crime scene investigations. It has become an area of expertise that SMX provides as a consultancy service.

Another ongoing collaboration is with a local university to develop a narcotics detection system which can be used for on-site drug detection. The university brings expertise on synthetic DNA, while SMX shares lessons learnt from previous drug detection cases and expertise on processes for analysis, especially current processes and approaches used in drug detection for the specific drug types of interest.

Furthermore, SMX has partnered with foreign government agencies to share forensic science expertise. While there are no immediate commercial outputs from such partnerships, SMX feels that they add significant value by expanding the knowledge base from which to proactively identify and prepare for potential issues in the field. Nick, who is managing the commercial side of the forensic division, explained that such exchanges are mutually beneficial. Giving an ongoing project as an example, Nick described how foreign agencies share knowledge about CBRNE[56] management in exchange for relevant DNA science and technology developed by SMX.

> "For us it's about building those relationships. They've got an agenda, we've got an agenda, but when they come together work for us respectively in our own areas, because we don't have an overlap in our jurisdiction. But the outcomes and the shared science can be good." (Nick, personal communication, August 09, 2017)

[56] CBRNE refers to Chemical, Biological, Radiological and Nuclear weaponry, terrorism and defence. More information can be found at https://www.natlenvtrainers.com/blog/article/what-is-cbrne

Apart from the projects outlined above, SMX is actively participating in university-based research activity via specific research projects funded either by SMX or government authorities, or through supervising doctoral and other research oriented academic programmes.

4.4.3 Revealing in SMX

As a government funded research institute, SMX is required to share knowledge created internally. Steve, partnerships manager for SMX, explained that all research activity has to have a predefined knowledge dissemination component that outlines relevant revealing activities.

> "A lot of the research we do has an expectation of public benefit. When we do bid in for research funding there's always the requirement of how we transfer that into learning, how we share the knowledge. All the research funding applications have an implementation pathway that is required. Within that we have to show how we transfer that IP." (Steve, personal communication, September 19, 2017)

Patric further pointed out that "forensic science is quite an open discipline" (personal communication, September 13, 2017). They have to consistently publish relevant research findings to gain the necessary validation for their evidence and expert testimony to be recognised by the courts.

Furthermore, the SMX workforce is predominantly made up of scientists with advanced degrees, such as research masters or PhDs. Therefore, as one staff member pointed out, their preference is for academic publications over commercialisation[57]. Not only do publications add value in terms of reputation and credibility, they also contribute to evaluating the performance of researchers in the firm. As a result, SMX seems to have a predominantly sharing based culture. In fact, Mike invited me, as a researcher, to make a presentation to the company focusing on the value of commercialisation within the open innovation paradigm. However, in recent years, SMX has established a commercial unit to overcome issues relating to their inexperience in commercialising research outputs.

Persuading researchers to protect proprietary knowledge prior to publication has been challenging due to the long-established sharing culture at SMX. Even though the firm has an IP policy, it is Patric's job to ensure that no proprietary knowledge is published before permission is obtained to disclose it (Patric, personal communication, September 19, 2017).

[57] From field notes, 2017.

However, this does not mean that knowledge is being kept secret. Public disclosure still occurs via patents or subsequent scientific publications.

Another key challenge for SMX in relation to collaborations is defining how much knowledge to share. As a public research institute, SMX is driven by a sharing culture. However, sometimes, sharing 'too much' or 'too little' can be disadvantageous.

> "There are always levels of sophistication around how people share their knowledge or their understanding or their willingness to share. It is never organisation to organisation. It is through individuals." (Patric, personal communication, September 19, 2017)

Collaborations are always initiated with a non-disclosure agreement (NDA) to prevent unintentional leaking of potentially valuable knowledge. Patric recounted incidents where 'too much' was shared before the necessary agreements had been put in place.

> "We are not actually concerned about ideas getting stolen. Generally, when people enter into collaboration it is done with good faith. There are some horror stories but in my 20 years' experience I've only ever come across a couple of examples where people have deliberately set out to what you would say 'steal ideas'." (Patric, personal communication, September 13, 2017)

However, he clarified that most discussion does not involve commercial content. Therefore, the 'damage' caused by such disclosures is not significant. He stated that it is much more significant when 'not enough' knowledge is shared to make good decisions around how to proceed. A main motivation for sharing knowledge is to 'upscale the partners' so that the returns for SMX will be improved (Mike, personal communication, August 09, 2017).

The main methods of revealing for SMX are through scientific publications and collaborative development. Collaborative projects always carry a publication stream, either in external peer-reviewed journals or internal platforms. Since the primary goal of SMX is to conduct applied scientific research, the firm participates extensively in academic publishing. Publications are important to the firm and its employees in several ways. First, SMX scientists are required by their job descriptions to conduct research and publish in peer-reviewed journals. They have a performance-based review process where the number of publications and presentations at conferences carries significant importance.

> "That is important for someone for monitoring their performance and being rewarded and recognised for developing their career. It is also really important when we want people setting up a track record to go for subsequent funding, for example, the funding applications require a principal investigator who is leading the work, and what's their track record. How do we know this person has the capability to do this, who have they worked with in the past, and what kind of experience do they have? A publication record is a really good way to do that." (Mike, personal communication, August 09, 2017)

Secondly, peer-reviewed publications provide validation for the methodologies used by SMX for lab work. Such validation is imperative for criminal investigations, especially when the

scientists must provide expert testimony in court. The validation achieved through publications guarantees the credibility of the witness and the analytical approach, as well as their findings and interpretations.

Thirdly, publications "formalise the outcomes of projects" (Mark, personal communication, August 09, 2017). Particularly for publicly or other externally funded projects, presenting achievements and outcomes is necessary to evaluating the project. SMX views publications as a means of summarising the activities of a project and succinctly presenting the outcomes.

Finally, SMX feels it is important to share research insights with the community for the purpose of replication, as well as to advance the science in the respective field. SMX uses knowledge published by other contributors in their specific fields for internal research and innovations. They feel obliged to reciprocate by sharing any improvements or novel findings in the science or technologies they work with. In fact, an employee of SMX characterised publishing as a part of being a scientist, claiming that scientists and engineers at SMX, as is the case in general, are more inclined to publish and disclose knowledge publicly than to protect their research through patents, or treat advances as trade secrets[58].

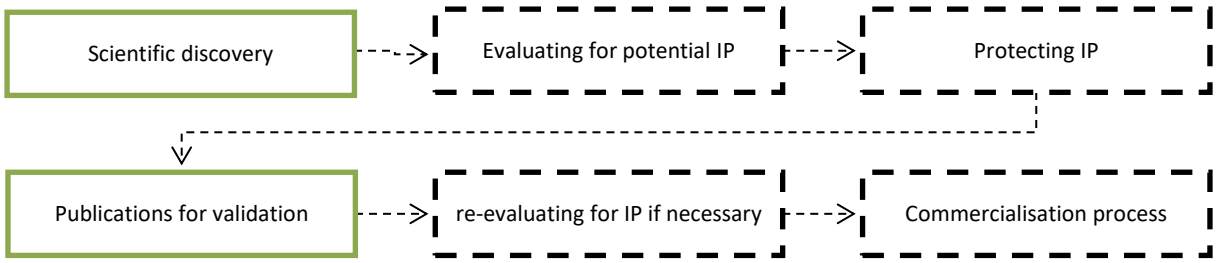

Figure 4-3: Disclosure-protection process at SMX

Explaining the importance to forensic science of being open and transparent, Patric, the commercial General Manager of SMX, emphasised that a valid and credible demonstration of the analytical processes used is vital in court.

> "By the very nature, forensic science is quite an open discipline. Because you need to share lot of information – a lot of the stuff that you do gets cross examined in court. So you have to be very open about how you go about doing things." (Patric, personal communication, September 13, 2017)

[58] Informal conversation. From field notes.

When developing the DIP software for DNA analysis, SMX evaluated a competing product that was "pretty much a blackbox" (Patric, personal communication, September 13, 2017). When analysts used the competitor's product for DNA identification, problems arose when demonstrating how the analysis was conducted. SMX therefore decided to disclose their algorithms and analytical processes via scientific peer-reviewed publications. This ensures that any party using DIP for DNA analysis can explain the process with credibility and provide validation for DIP in court. Disclosing otherwise proprietary knowledge such as the algorithms is a trade-off SMX makes to further develop the field of forensic science.

> "That [disclosure] meant we have to back ourselves to stay ahead of the competition because so many people would have access to our core algorithms and IP. It was a very open decision to make but it also led to commercial returns." (Patric, personal communication, September 13, 2017)

With DIP, the company instead created a business model around the services it provides to support DIP, including access to upgrades, training, maintenance and support. The community of DIP users has regulated access to an online platform (restricted to the community) with information pertaining to the use of the product, as well as information on how to handle demonstrations during legal investigations.

> "The openness continues in the collaboration we formed, in the way that we collaborate with other researchers, the way that we hire people to work with us. We have a strong community of practice as well. So if you are a [DIP] user, you get access to all of the information that we use for courts. We have information on our closed website [an intranet or a community access web page] around how to answer specific questions you may get in court." (Patric, personal communication, September 13, 2017)

Even in the TDV project, when SMX attempted to develop virtual reality visualisation of crime scenes, the development process involved intermediate publications throughout. However, Mike clarified that the papers were not submitted to peer-reviewed journals, but only published internally. Once the board of SMX decided not to pursue the commercialisation process, Patric and the commercial team considered revealing the source code for TDV or applying for crown copyright protection. However, this has not been actioned due to concerns about the individual/s who created the source code, and how their interests can be protected.

Patric pointed out that the most important benefit of revealing knowledge, either through publications or to partners via collaboration, is the potential inflow of knowledge for innovation, as well as for the greater good of NZ in general. In terms of benefits to SMX, the development of DIP is a 'once in a lifetime commercial opportunity' (Patric, personal communications, September 13, 2017). Not only do such revealing activities create potential revenue flows, they are valued for building reputation, as well as forming pathways to potential partnerships.

Using as an example the collaborative effort to develop a vaccination for influenza epidemics, Patric explained how the inflow of knowledge to SMX resulting from collaborations and knowledge sharing leads to much wider benefits beyond the firm.

> "We do attempt to evaluate and put dollar value. But it's a very complicated economic analysis. We could say we helped reduce crime or solve crimes, but then there are so many other contributors to it. It is very difficult to put value to a portion or compare the different components to the whole. We try to demonstrate these but unfortunately we can only resort to the stories or anecdotes." (Patric, personal communication, September 19, 2017)

He stated that the knowledge received through the partners, who were from both local and international institutes, influenced how the vaccination was developed and ultimately contributed to revising public health policy in NZ. However, evaluating such benefits received has been a challenge.

4.4.3.1 Revealing process and activities

As a government funded research institute, SMX is mandated to share research output openly and freely. However, they have some leeway around revenue generation through IP appropriation to maintain their viability. As Steve and Tod from the commercial team pointed out, forensic science research has fewer funding opportunities compared to environmental or health research. Therefore, SMX has to consider a balance between 'private and public' knowledge appropriation (Steve, personal communication, August 30, 2017).

Table 4-8 presents key strategic actions taken by SMX in the revealing process. These strategies are aimed at enhancing the potential outcomes of knowledge outflows, while adhering to the requirement for knowledge sharing. While not initiated by SMX, but rather as a requirement in funding applications, all research projects have to have a predefined action plan for revealing the knowledge outputs. The research team identifies and outlines potential methods for revealing knowledge components, as well as the nature of revealing for different components – for the public good, privileged, or private. This enables the firm to modularise the knowledge, similarly to how they segmented knowledge in the DIP project. For the DIP project, SMX published all the algorithms around the product and other necessary analytical procedures used, but the source code and the firmware remain a trade secret. The source code is processed (also known as compiling) to create the machine-readable DIP software, which is provided free to local authorities but is licensed to international counterparts.

Once the knowledge outputs are ready to be shared, they go through an internal validation process where a combination of methods is used, such as peer-review for scientific accuracy

and presentation, and IP review to identify knowledge components that may potentially need patenting or to be kept secret.

Table 4-6: Strategic actions used in SMX

Action	Purpose	Evidence
Systematic planning of revealing activities	Primarily as a requirement of the grant application; Ensures that the subsequent knowledge components are identified, and suitable revealing methods are predefined.	"When we do bid in for research funding there's always the requirement of how we transfer that into learning, how we share the knowledge. All the research funding applications have an implementation pathway that is a requirement. Within that we have to show how we transfer that IP. E.g. now we are building sensors for the tracing of pathogens in water. Within that funding process, we have indicated how we will transfer the knowledge to, for example, councils in NZ for free; other private entities in NZ who can exploit it further work." (Steve, personal communication August 30, 2017)
Internal review process	To mitigate the risks of oversharing; Identify and protect proprietary knowledge before open publication.	"There is a process that the employees need to go through for external publications – papers, conferences, posters. Once they've written their drafts, it is reviewed by, depending on who else is involved, one of our agents who works with one or two independent peer reviewers, so people who aren't part of the project but still from [the firm] - so internal peer review." "And we do that because we need to make sure it makes sense, we have done the right things; to check if there is potential intellectual property to be reviewed…" (Mike, personal communication, August 09, 2017) "I have an IP register. But it is not widely available." "Right now employees have to go through me to find out if a certain IP is disclosable or not." (Patric, personal communication, September 13, 2017) "But there will be peer-review internally as well as collaboratively, if there are partners like universities. Obviously for PhD students, they go through a process, or end up embargoing the publications because they have developed some unique science that may have a commercial value." "It may well be we actually get the correct protection in place before we can be more open about it. We put some mechanisms to protect it to a point within reason because in many cases, the value is in the trade secret not necessarily in the science itself." (Nick, personal communication, August 09, 2017)
Intermediate sharing	To increase awareness of the ongoing projects; Identify potential collaborative or license partners.	"Once the project is underway we try and find ways to keep that information being shared as we kind of develop it. So if someone is going to a conference what about our current project or list of projects that we could share; if a drug analyst expert going to an international conference they'll present on their research; but are there other things that we could get

Action	Purpose	Evidence
		them to talk about; are there companies that are going to be there that we could target as possible partners in a future project or anyone who might be interested in using the things that we are trying to develop, something that we could get protected or something novel that we may want to look at licensing." "It works as a solution. It get validation track records in some publications." (Mike, personal communication, August 09, 2017)
Upscaling partners	To ensure the knowledge inputs are beneficial to SMX	"Some of the knowledge sharing would be because we want a reliable outcome in a project or a piece of work. A part of it is because we want to upscale whoever we are working with or to give them an insight in to how their part of the work would be relevant or useful to us. We do that because it improves what we get back." (Mike, personal communication, August 09, 2017)

Even with such a process in place, Patric pointed out there have been instances where they have had issues around IP protection.

> "What really happened was [Scientist] submitted the publication, and it was about the time we were talking about actually this is something we need to get filed [patented]. So what happened is we went through a review and accepted the publication and that provided us the publication date and we were working towards that. Little did we know that it actually got published online a few days earlier than we were expecting. It is currently working against us at the moment." (Patric, personal communication, September 19, 2017)

This shows when the knowledge components become subject to an interconnected mix of IP rights, such as between publications, and patents for example, there has to be a priority process to decide which activity comes first.

This is important, especially when the firm uses intermediate sharing during the innovation process. In most instances, SMX shares knowledge continuously throughout the research process. Mike explained that this is to make the community aware of the ongoing research, or potential SMX products, as well as to identify potential partners for future collaboration. Intermediate sharing further acts as a commercialisation pathway to find potential licensees for existing SMX products.

As seen earlier under innovation projects, SMX collaborates with various partners to conduct joint research, as well as in providing forensic services, and this is also essential to internal knowledge creation. Therefore, ensuring that the partner also follows quality standards and protocols in their forensic work is essential for a quality output. For example, when a sample from a crime scene is retrieved for analysis, the retrieval is conducted by another agency. If the

agency does not follow appropriate protocols to retrieve the sample, the effort invested by SMX in the analysis may be wasted. Because such 'real cases' provide numerous research opportunities for SMX, ensuring that partner agencies are trained in appropriate standards and protocols is vital. The aim is not only to develop a mutually beneficial outcome, but also to gain valuable inputs for SMX through the collaboration. As a strategic action, this further ensures that the knowledge revealed by SMX is both accurate and useful for any purpose.

4.5 Case firm 4 – RQL

4.5.1 Background of the firm[59]

RQL is a pioneering manufacturer of air quality sensors and fully owned and operated in New Zealand (NZ). It was established in 2001 by its two co-founders, who co-owned the patent for an innovative air quality sensor. One was and still is a renowned professor in a leading university in NZ. The other co-founder, Vince[60], was a leading researcher in the field of Material Science at the time, and now serves as the Chief Technology Officer for the firm. Today, RQL employs a workforce of at least 30 permanent staff, which includes an in-house R&D team, a commercial team, and an operations team.

RQL strives to maintain an almost 99% export margin (Vince, personal communication, July 05, 2017). Its clientele is spread over more than 50 countries, including China, India, UAE, USA, and South America. In 2014, RQL's efforts to become a global brand received a boost from the NZ government when it was selected as a Focus700 company. This is a co-investment project implemented by NZ Trade and Enterprise to help export companies maximise and grow their exports and "create new value or add value to existing activities" for firms in a way that transcends mere sales (International Growth Fund, www.nzte.govt.nz/, viewed on 20 August 2018). RQL qualified for this investment fund due its strong collaborative approach to product development and deployment with international agencies.

The CTO explained that RQL competes in the *non-certified equipment* market, where the equipment used for air quality monitoring is not certified by regulatory bodies such as the United States Environment Protection Authority (USEPA) and European Union (EU). Equipment that meets the requirements of certification tends to be bulkier and therefore more power-hungry. Even though the non-certified market is about one-fifth the size of the certified

[59] Information from interviews, company web and news articles.
[60] A pseudonym.

equipment market (projected to reach US$ 20 billion by 2021), it has a comparatively faster growth rate due to being able to customise products more easily (Vince, personal communication, July 05, 2017). RQL has been successful in exploiting this market by being innovative in their equipment design, delivering on quality and accuracy in measurement, and producing lower-cost equipment.

Nevertheless, the company has still met quality standards and certifications such as ISO and MCERTS[61] for their products, as well as the organisation.

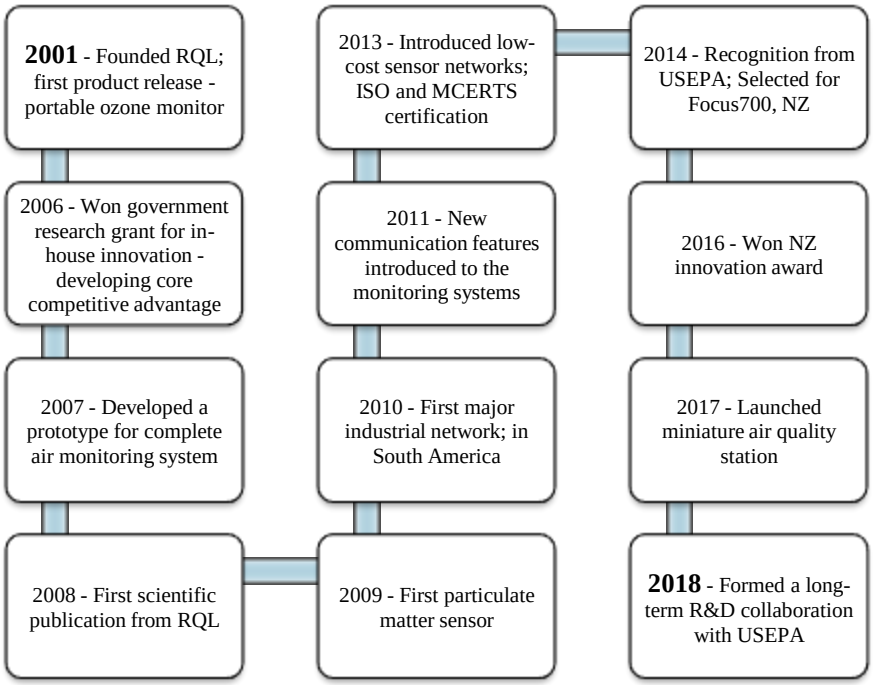

Figure 4-4: RQL milestones: Timeline information sourced from the RQL website and interviews

RQL has experience and expertise in air quality monitoring across diverse environmental conditions, ranging from deserts, to high-density populations, to rain forests and ice glaciers[62]. Due to their innovative nature and the success achieved in such diverse contexts, RQL has been listed in several recent independent market research reports[63] as one of the top 10 makers of air

[61] Environment Agency's Monitoring Certification Scheme for equipment, personnel and organisations, awarded by the CSA group (www.csagroupuk.org/services/mcerts/)
[62] RQL website, viewed 15 August 2018
[63] Appears in market research reports from WiseGuy (www.wiseguyreports.com) and Technavio (www.technavio.com) from 2015 to date. Although these reports could not be accessed directly, third-party news sites such as PRNewsWire confirm these claims.

quality sensors and particle monitors worldwide. The firm was also recognised at the NZ innovation awards for developing the most innovative hardware solution.

4.5.2 Innovations and projects of RQL

RQL develops product innovations in measuring air quality, which includes the equipment as well as technologies relevant monitoring and communicating air quality. Core products of RQL include their individual air quality monitoring sensors for various gases and particulate matter (PM), as well as fully integrated instruments such as portable monitors, and low cost, miniaturised indoor and outdoor monitoring stations. These products are recommended by agencies such as USEPA and the UK's Environment Agency. According to the CTO, RQL's core competencies lie in its sensor technology, measurement algorithms and instrument development (Vince, personal communication, July 05, 2017). The sensor technology developed by the co-founders in 2001 was the first in the market to achieve high quality ozone (O3) measurements. The CTO further claimed that RQL has the best sensor technology in the market, and this is also acknowledged by independent bodies.

> "We've tested them against certified equipment and they have very high performance and very high accuracy levels, almost equivalent to the reference. This is proven through independent studies. USEPA have our products on some of their guides as a good product." (Vince, personal communication, July 5, 2017).

Because the firm already possesses the know-how for developing algorithms needed for highly accurate sensors, they have been successful in improving instruments bought off-the-shelf.

> "Because we can measure ozone quite accurately, we can buy other sensors off the shelf and improve their measurement. We have the know-how around how to make good measurements – partly because we have been doing this since 2008 and has almost a 10-yr. head start from everyone else." (Vince, personal communication, July 5, 2017).

RQL's innovative sensor technology was commercialised as a portable handheld air quality monitoring device in a rising US market in the company's first year of operation. Subsequent models of these portable devices are low-cost, highly simplified and so user friendly that school children and commercial customers alike can use them to obtain accurate air quality measurements.

Among other significant innovations from RQL are their complete air quality monitoring stations, which are small and can be mounted in outdoor locations. According to Vince, the traditional air quality monitoring station is the "size of a caravan" whereas RQL stations are "about the size of a suitcase" (Vince, personal communication, July 05, 2017) These miniature monitoring stations are highly popular due to being low-cost, small and energy-efficient, which

appeals to government agencies looking to implement air quality monitoring in cities and other localities.

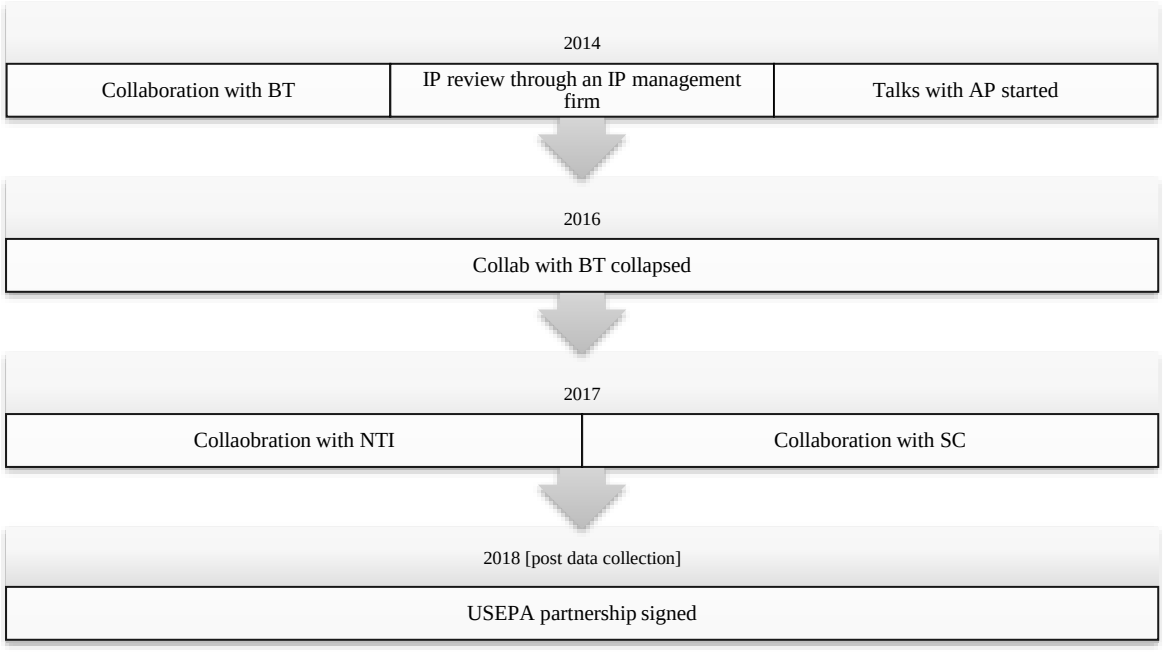

Figure 4-5: A timeline of key RQL projects

While some RQL products are completely developed in-house, the majority of instrument development is done in partnership with a local instrument manufacturer, NTI. In 2006, RQL was granted funding by the NZ government, which they used to move the design and fabrication of products in-house to maintain their core competitive advantage. The Vice President of Product Development, Will, stated that RQL continues to collaborate for R&D activities, but not for co-development.

> "A lot of them [collaborations] are more R&D than product development collaborations I would say. Because a lot of them have not made it through to a product. They made to a prototype. But not to a finished product." (Will, personal communication, August 29, 2017).

Table 4-7: Summary of RQL's key innovation projects

Year	Project	Purpose	Type of innovation	Knowledge flows	Outcomes/ Inputs
2014	BT	To develop a low-cost air quality monitoring system.	Product innovation	Collaboration involving an outbound knowledge flow. RQL revealed knowledge in return for sales revenue.	Sales revenue from sensors; information on market opportunities for low-cost air quality monitors. Did not receive the anticipated sales revenue that drew RQL into the partnership.

Year	Project	Purpose	Type of innovation	Knowledge flows	Outcomes/ Inputs
2017	NTI	Develop the PM sensor	Product innovation	Collaboration that involved inbound and outbound knowledge flows. RQL revealed the knowledge on sensors for NTI to design and manufacture the sensor.	Due to their long-term relationship and mutual understanding, a fast product-to-market time
2017 (in progress)	SEPA	Co-develop low-cost air quality monitoring solutions for smart-city applications	Product and process innovation	Collaboration with both inbound and outbound knowledge flows. RQL reveals knowledge on sensor technology and precision measuring, while SEPA shares their infrastructure and knowledge on smart-city applications.	Expected: Air pollution measurement capabilities; access to extensive air monitoring infrastructure; access to innovative market spaces; potential to develop new products and tech – low-cost sensors, remote calibration technologies, and accumulate long-term independent test data.
Ongoing discussion (potential)	SC	Potential to develop an integrated network that monitors air quality and communicates results to users	Product – application specific	Both inbound and outbound knowledge flows. RQL reveals monitoring system technology in exchange for smart city network capabilities. Potential for selling knowledge on interpreting the data to clients.	So far: valuable market information on smart-city applications. Expected: sales revenue from sensors and monitoring systems; accumulate sensor data from multiple sources
Ongoing discussion (potential)	AP	Still unclear about exact goals. Potential to develop personal air quality monitoring systems – miniaturised.	Product and process	Collaboration with both inbound and outbound knowledge flows. RQL will reveal knowledge on portable sensor and integrated air quality monitoring technology while AP share their expertise on scaling equipment for portability and personal use and provide access to a large personal consumer base.	So far: information on partner's interpretation of the potential market opportunity – personal level applications of air quality monitoring. Expected: knowledge on scaling instruments/sensors for portability and personal use; access to accumulated sensor data.

These collaborations are instrumental in identifying new product ideas, new market opportunities and developing new applications for existing products. The miniaturised monitoring stations are an outcome of one such partnership. While the partner firm did not

contribute know-how to developing the stations, the partnership was instrumental in identifying market demand and opportunities.

The development of the particulate matter (PM) sensor for the handheld monitor was an innovation that required a collaborative design effort due to RQL not possessing the resources to develop it in-house. In this case, RQL joined manufacturer NTI to form a partnership that eventually developed the PM sensors.

NTI had been manufacturing instruments for RQL since its inception and they therefore had a strong ongoing relationship that has made the partnership an easy one.

> "It was a lot more comfortable because we've done it before and we [*NTI and RQL*] were close. (Will, personal communication, August 29, 2017)

Leading laboratory instrument manufacturer (BT) approached RQL with a proposal to form a partnership to develop "low cost air quality monitoring and a network of monitoring instruments" (Vince, personal communication, July 05, 2017).

BT initially approached RQL to purchase an existing RQL product for the purpose, potentially involving the sale of an estimated 10,000 instruments. However, RQL needed to heavily customise the product to enable successful integration into BT systems, which required a contractual agreement between the parties. RQL ended up sharing a significant amount of know-how around the around the product, as well as investing time and effort in training BT's development team to make the integration a success.

> "We tried to put in a contract where we would provide them with the R&D support and technical support during their development phase. But actually, they didn't want that, they did not want to pay for that. They wanted it for free." (Vince, personal communication, July 5, 2017).

However, BT subsequently decided that the planned project might not deliver the expected returns to the firm, and therefore ended the partnership after two years. While RQL still made sales of "few hundreds of instruments" (Vince, personal communication, July 05, 2017), it did not receive the benefits anticipated from the partnership. Vince described it as a failed collaboration where significant know-how had to be shared, but which did not deliver a significant return.

> "That is an example where you attempt to go into partnership in an open manner, you invest time and effort that can lead to nothing." (Vince, personal communication, July 5, 2017).

At the time of the interviews, BQL was in discussions with a leading personal communications device manufacturer (AP) about potential opportunities around personal air quality monitoring

solutions. While they had not been in a co-development partnership before, Will stated that this might have the potential to turn into one.

> "So far our partnerships have been we supplying something that other people integrate into their system. With AP, we'd be supplying know-how, and IP and getting a royalty I think. And they would be doing the end-to-end fabrication. It's quite different approach." (Will, personal communication, August 29, 2017)

Another ongoing discussion at the time was with a smart cities network provider (SC) around producing air quality monitoring systems that are mountable in various locations across a city. The idea is to integrate the monitoring systems into a smart network that is Internet of Things (IoT) enabled, to provide continuous and meaningful air quality data to the citizens of the locality. Vince believed that this project could provide RQL with the opportunity to develop a complementary partnership that ends up creating mutually beneficial products.

> "It is a very exciting project, they've got core competency that is complementary to us. So we don't need to know their competency, or they don't need to know our competency very much. But we can work together and share just enough to enable both parties to do their job." (Vince, personal communication, July 05, 2017)

RQL recently entered into an R&D partnership with a national environment protection agency (SEPA) to co-develop low-cost air quality monitoring solutions for smart-city applications[64]. In this collaboration, SEPA will provide the necessary access to infrastructure and its current expertise on smart city applications and air quality measuring standards, while RQL extends the existing knowledge on sensor technology, precision measuring and calibration technologies. The ultimate goal of the collaboration is to develop low-cost "Next Generation Air Monitoring tools" that are more accessible to a wider community encompassing scientist as well as the general public (SEPA website, viewed on August 20, 2018).

4.5.3 Revealing in RQL

RQL reveals, but within limits. They do not consider themselves extremely open. However, as CTO Vince stated, they conduct a considerable amount of collaborative innovation, as well as research work. Vince believes that collaborative partnerships are important to grow the firm in a competitive market. He emphasised RQL is interested in building 'partnerships' rather than 'collaborations'. As defined by Vince, a partnership is a long-term relationship that is built and nurtured on trust. Section 4.2 outlined a few key projects RQL is involved in that have revealing aspects. Although the majority of their collaborations are not co-development partnerships that

[64] Information through SEPA and RQL webs and third party news sources.

produce a completely new product (i.e., not radical innovations), all involve significant knowledge flow from RQL to the partnership and have resulted in incremental developments to existing products, and new applications as well.

According to Will, the collaborations have been highly significant for distribution, customisation and developing complementary products. However, he pointed out that past collaborations, especially the co-development partnerships, have not provided significant, IP related knowledge inflows for internal innovation.

> "What is happening in the technology space is very important for that. Visiting companies in the same domain as us. That is really useful. But I don't know so much about if the co-developments have done that for us. I cannot think of an example where it has helped." (Will, personal communication, August 29, 2017)

But he added that the potential partnership with AP could change this. AP has technical knowledge around scaling products to suit different requirements, and that will be valuable for RQL's production process.

The challenges experienced by RQL with regard to revealing are specific to issues around collaboration. The main barrier has been communication issues with potential partners. RQL experienced issues in the early discussions with both AP and BT, where the revealing effort from RQL was not equally reciprocated. Proceeding with discussions for a future partnership then becomes difficult in such situations due to perceptions of unreliability and lack of trust. Vince explained that collaborations initiated with shortcomings or lapses in communication will likely not last, nor produce beneficial outcomes. The BT project was an example.

> "The difficulty was that when you work with a large corporate they [BT] have their own development team and their own IP arrangements. Even though we had an NDA in place, the communication wasn't that strong"

> "The barrier is they think they know best, so what could happen is that they go down a route which ends up not working and they don't want to include you in that process often."

> "Actually, we ended up providing them [BT] with our know-how and understanding without getting any value from them." (Vince, personal communication, July 05, 2017)

Another challenge is "understanding the risk-reward equation" (Vince, personal communication, July 05, 2017). This relates to the challenge of finding compatible partners in terms of technology, corporate strategy and knowledge base. When collaborating with larger corporations, the investment they make in the collaboration is sometimes not as significant to them as it is to RQL – as the smaller player. If the efforts from each side are not equal, RQL ends up losing a significant amount of resources compared to the partner.

> "They don't want to pay for that knowledge or they don't want to include you in that process, or they want to include you in the development process but want it to be free because they are offering a huge opportunity for your product. The problem with that is if you do that and it fails you've invested a whole bunch of time; in case of large corporate you don't have a whole lot of control over the outcome. Because their strategy may change at any point." (Vince, personal communication, July 05, 2017)

Vince clarified that almost all the partnerships they had been involved in so far were bipartisan. Being a relatively small firm, RQL does not have sufficient experience or the resources to manage multi-party partnerships and still protect their competitive advantage. According to Vince, co-development is a resource-draining process where all parties need to be highly committed. Because RQL is a "low-volume, high-value" firm, and small in size, they are disadvantaged in the value capturing process. One example of this was their partnership with BT. BT had outsourced their R&D to another firm, a situation that RQL was not aware of until they visited the facility to train personnel on how to use RQL products. Even though the third party had an NDA with BT, Vince viewed this as a lapse in communication.

> "The difficulty was that when you work with a large corporate they have their own development team and their own IP arrangements. Even though we had an NDA in place, the communication wasn't that strong." (Vince, personal communication, July 05, 2017)

AP was another example where the communication had been "one-sided" (Will, personal communication, August 29, 2017). During the initial discussions it was apparent that AP was not ready to share their strengths, weaknesses, or their intentions in approaching RQL.

> "During the call [*first contact*] it became clear that they are going to tell us nothing about what they wanted to talk about. They told nothing about their motivations for contacting us. So we didn't disclose anything at all either actually. They wanted us to prepare a presentation and tell about our sensor technology. We declined. We said 'No, it's going to take too much work'. It was one way communication." (Vince, personal communication, July 05, 2017)

After "they did the dance" (Will, personal communication, August 29, 2017) of going back and forth with discussions, AP eventually realised the merits and potential benefits of partnering with RQL and they were currently exploring possible co-development opportunities. But the process of building trust and agreeing to contractual terms becomes drawn out when such challenges surface in the early phase of discussions.

> "As a small company, these kinds of interactions can take a lot of resources and they can lead to NOTHING! So you have to be very careful as a small company when engaging in these sorts of opportunities you can spin your wheels a lot and not get any benefit from it." (Vince, personal communication, July 05, 2017)

Vince viewed such communication barriers as destructive to partnerships, especially when working with larger corporations where the risk is skewed towards RQL.

> "… The biggest challenge is understanding the risk-reward equation; deciding how much resource the opportunity warrants."

> "… the concern is, are the risks equivalent for both? If not one would feel a bit aggrieved. They are risking more, and that is hard to make that work well. A lot of cash from a large firm is not the same as the risks experience by a small firm like RQL from a business sense." (Vince, personal communication, July 05, 2017)

RQL commits more to a collaboration when there is a long-term relationship built on trust between the partners. Therefore, they prefer to "spend more time getting to know the partner" (Vince, personal communication, July 05, 2017). They use the strategy of personifying organisations as an individual[65], usually the main contact, to understand their nature, work-culture and knowledge needs. The meeting room had displays of such exercises for visualising the organisation as a person.

> "May be looking for a small project initially and if that works well, scaling that up. That process helps to de-risk them." (Vince, personal communication, July 05, 2017)

They believe that trust between partners is crucial for knowledge revealing, even with NDAs and other legal arrangements in place.

The main mechanism for revealing used by RQL is through collaborations. All collaborations begin with discussions to understand the requirements of the partner, their capabilities, strengths and weaknesses, as well as provide information on the strengths of RQL. If both parties view a partnership as mutually beneficial, the next step is to sign a non-disclosure agreement (NDA), and subsequently move to due-diligence procedures such as facility visits if necessary. The initial discussions focus on four key questions: "1) What they [potential partners] try to do?, 2) What have they tried so far?, 3) What is their point of default?, and 4) Why us [RQL]? What do they gain from working with us?" (Will, personal communication, August 29, 2017).

> "We kind of have a process where we do most initial calls even if we think it is going to be a waste of time just as a learning exercise." (Will, personal communication, August 29, 2017)

Even with an NDA in place, RQL still has to make strategic decisions about what knowledge can and cannot be shared. Therefore, the management team identified the need to catalogue their knowledge in order to streamline the selectivity of disclosure process.

> "At the time [*during the discussions with BT*] we realised we needed to have some rules around disclosure. We threw an exercise of evaluating our IP, know-how, our trade secrets and categorising it. And then

[65] Field notes: evidence of such client/partner analyses was displayed in the meeting room.

> putting in place a process by which depending on the category, you could disclose or not. So you could disclose it under certain conditions. So there were things that you would never disclose, they wouldn't ever be disclosed even with an NDA. There were things that could be disclosed with an NDA. And there were things that could be disclosed without an NDA to certain types of people, and then there were public [category] – things that could be displayed on our website, etc." (Vince, personal communication, July 05, 2017)

The catalogue was developed with the assistance of an IP management firm, to identify the knowledge components for the firm and assign a level of disclosure to them, or as RQL terms it, "a bucket". The basic categories comprise five buckets, ranging from 1) trade secrets that will never be disclosed to 5) public documents[66]. Vince added that the process of cataloguing also includes detailed guidelines for how to categorise future knowledge components into these established five levels, or, alternatively, re-negotiate the current disclosure levels.

This 'IP policy', as RQL calls it, has been instrumental in a number of collaborations, especially during the early pre-NDA discourse, to decide what knowledge could be disclosed. Vince provided further examples where the situation called for re-negotiation of the bucket a certain knowledge component belonged to.

> "One of issues for that company [NTI] to do the work, was they needed access to our source code for the firmware that we have developed in-house. We looked at our IP catalogue and the source codes of any products are trade secrets and should not be disclosed even with an NDA. But then we revaluated that source code and realised there are some source codes who have more core technology than others. Some codes were proprietary but did not contain any core knowledge or core-competencies. So we realised we had to differentiate between different types of source codes. Once we revaluated those buckets, we realised that the source codes to the PM sensor weren't a trade secret and could be disclosed under an NDA. So we revised that category. That enabled the project to go ahead." (Vince, personal communication, July 05, 2017)

Will (product development) and Zander (commercial) reported that decisions involving revealing knowledge are mostly taken by Vince. Vince makes the final decision on its application during collaborations, especially when re-negotiation of *buckets* is required, after considering input from the product development and commercial teams. However, the *IP policy* is accessible to all employees of RQL.

> "By having categorised it [*knowledge*], if there is a conflict – e.g. they need this bit of information that we've said is trade secret – we look at the commercial over lay: do we need to disclose this to get good commercial benefit? If we say yes, because the commercial opportunity is really exciting, is there a way of disclosing it that will still protect us? If so, then we'd fine-tune it." (Vince, personal communication, July 05, 2017)

[66] Adapted from the confidential document, sighted July 05, 2017.

Among other methods of revealing, RQL actively participates in scientific publications and conference presentations via university collaborations. Publications provide the necessary validation and credibility for the technologies developed by RQL. However, prior to publishing, RQL ensures that as per their IP policy, knowledge components are protected or secured with IP rights as necessary. Vince, who has a PhD, viewed publications and conference presentations as a means of promoting the non-certified equipment market, i.e., it helps the industry to grow.

> "It is also important from a credibility point of view – that we do scientific research to strengthen the performance of our instruments. We use credible approaches to show how our instruments can be used, and we want to tell that story. So that is about conferences – explaining how to use our equipment to generate new information that would be difficult to get in any other way; demonstrating the usefulness of our instruments." (Vince, personal communication, July 05, 2017)

Will clarified that the revealing activities of RQL are not aimed at creating innovations, but rather at adding other types of value such as knowledge inputs, market information, and even sales revenue. The project outlines in section 4.2 describe the outcomes received or expected through the collaborations.

While no formal process is in place for evaluating the specific outcomes of RQL's revealing activities through collaborations, projects are evaluated while still in progress to identify the inputs for the firm, and at the end to identify the lessons learnt. Vince explained that these ongoing evaluations help them to understand the different work cultures of their partners and the risks attached.

> "If the cultures are similar – similar approach to disclosure, how you work, and communication – then the partnership can work well. If the cultures are different, - very tightly controlled legal process for disclosure, different processes, - that becomes difficult to work well.
>
> The next concern is are the risks equivalent for both? If not, one would feel a bit aggrieved. They are risking more, and that is hard to make that work well. A lot of cash from a large firm is not the same as the risks experience by a small firm like RQL from a business sense." (Vince, personal communication, July 05, 2017)

According to Will, the lessons learnt are useful for future collaborations, especially when they indicate ways of handling the challenges faced. Furthermore, the lessons from collaborations that do not proceed to producing products or other outcomes are also important.

4.5.3.1 Revealing process and activities

RQL is comparatively restrictive in its revealing activities, using strategies aimed at delivering only the knowledge components necessary to initiate and maintain partnerships. The firm's deliberate exercise to modularise their knowledge base into 'buckets', as explained in section

4.3, ensures that anyone from RQL has the necessary information to decide if a particular 'piece of knowledge' is disclosable or not. This simplifies discussions with potential partners. The firm has also exercised vision in including guidelines in their so-called IP Policy document clearly defining and outlining the process required to re-negotiate the 'buckets' if the need arises. This shows that the firm has indeed learnt from partnering exercises, as explained by Will.

Table 4-8: Strategic actions used in RQL

Action	Purpose	Evidence
Knowledge catalogue	Modularising the IP base of the firm to enable quick and easy decision making with regard to disclosing	"Three years ago we undertook a review by an IP consultant and looked at what good IP we have, how we might protect it but also how we manage it in terms of working with other partners. One of the things we realised is that for the trust to grow, we need to partner. So we need to understand what we can and cannot disclose. It is really about thinking through how we protect and manage our IP." (Vince, personal communication, June 29, 2017) "We have our IP strategy as I mentioned. So we know what we can and can't talk about." (Will, personal communication, August 29, 2017) Document sighted on July 05, 2017 at RQL premises.
Guidelines to re-negotiate the IP buckets	To provide flexibility when discussing potential partnerships	"There was a case recently where we needed to share some firmware relevant to the sensor head component. To share that with NTI… that would have been against the policy, so we actually changed the policy in that case." (Zander, personal communication, August 14, 2017) Document sighted on July 05, 2017 at RQL premises.
Design thinking approach	To understand the partners and their knowledge requirements	"Our preference is to spend more time getting to know the partner." (Vince, personal communication, July 05, 2017) "Vince explained the displays on the meeting room we were having the interview in. The walls were occupied with different profiles of potential customers - who they sell to in this instance, not the partners. They have personified the company to the person they have contact with – a design thinking technique. They use the same technique for partners too." (extracted from meeting notes taken on July 05, 2017)
Collaboration process guideline	Informal: to establish the basics for initial discussions	"Not exactly a checklist but we would typically try to understand - what are they trying to do? What have they tried so far? What is their point of default? Why us? What do they gain from working with us? We kind of have a process where we do most initial calls even if we think it is going to be a waste of time just as a learning exercise." (Will, personal communication, August 29, 2017)

One of the key challenges faced by RQL when collaborating is to understand their partners. Zander, VP Commercial, feels that RQL still has to learn how to collaborate effectively to arrive at much better and more valuable outcomes. They utilise a technique for empathising to understand their customers that is part of the design thinking approach to innovation. The displays in the meeting room showed that this is a practice the company used regularly. They use a similar approach to understand potential partners in the early stages of discussions. A part of this process includes the basic guidelines referred to by Will that are used in the early talks. Although not a formally established process, the four questions the discussions focus on enable the team to draw some conclusions on the type of collaboration they might enter into.

RQL is selective in its revealing activities, both in terms of access as well as content. They carefully select the partners they want to share knowledge with after weighing the trade-off between revealing knowledge against the potential benefits – commercial or intangible. The main method of revealing in RQL is through collaborative partnership where RQL shares technical expertise, materials such as documents, and equipment, as well as providing hands-on training. They are also actively participating in research projects in universities, where the findings are published on scientific platforms and presented at conferences. RQL ensures that all knowledge components are captured and protected via suitable IP rights, or classified as trade secrets, before any publication or presentations are carried out.

4.6 Case firm 5 - TTR

4.6.1 Background of the firm[67]

TTR was founded in 1969 by a New Zealand (NZ) innovator and radio enthusiast with 12 radio technologists on board. Ever since it has been a pioneering manufacturer of radio communications. Headquartered in NZ, today TTR employees more than 650 staff in seven offices spread all over the world and has exclusive dealer partnerships in more than 150 countries. TTR's clientele includes police, ambulance services, mining companies and transport networks in a number of countries.

TTR has been committed to research and development since the beginning. The founder's business philosophy was to reinvest all profits in research and development, and cutting-edge

[67] Information on the firm was sourced from secondary sources such as the company website, company blog and news sites

manufacturing technologies. As a result, they were able to develop a series of award-wining Miniphone mobile radios within the first few years of establishment.

> "Our technology is our sword, we keep it sharp and bright." (late Founder of TTR, TTR web, n.d.)[68]

Since then, significant incremental innovations to the mobile radio and communications equipment have gradually taken place over time. Among other significant innovations in the early 1990s were sophisticated mobile data solutions such as automatic vehicle location trackers, electronic fund transfer terminals in automobiles, and a new version of their portable radio range that was the culmination of advanced software design and automated manufacturing.

Due to their success with production and technology in the early years, TTR was already exporting 25% of its production and had a wholly owned subsidiary in a foreign country within the first decade. Subsequently, their network of subsidiaries has expanded across two continents. While TTR maintains a wide global presence, 95% of their products are still manufactured at their NZ headquarters.

The founder of TTR remained true to his vision for the company to remain 'New Zealand owned', rejecting acquisition offers from foreign corporations. He subsequently restructured the company as a charitable trust to prevent anyone from selling the firm to foreign investors. He was also adamant about making valuable contributions to employees, the community and clients through the company, a practice that still continues in TTR.

4.6.2 Innovations and projects of TTR[69]

TTR's core product is their mobile radio communications systems. TTR products are compatible with a range of communications network standards such as P25 and DMR. From its inception, the majority of the company's innovations were developed in-house. They predominantly focused on incremental improvements to their communications technologies and equipment. Among significant path-breaking innovations of TTR are their durability standards and an integrated communications solution for vehicles[70].

[68] Extracted from the TTR website, accessed on June 01, 2018.
[69] Information from interviews with the R&D manager and Chief Technology Officer, researcher's field notes, TTR blog posts and news articles.
[70] Information from TTR website and blog posts.

TTR's durability standard (TDS)[71] ensures that the devices with a TDS label are capable of enduring multiple levels of hardship and tough situations without failing. The R&D for TDS began in early 2013, and the standard has been tested under numerous toughness conditions to check for endurance. The integrated communications solution (TCS)[72] developed for vehicles combines LMR technology with Wi-Fi Push-to-enable-talk-over-cellular (PTToC) (discussed later in this section) technology and on-board computing technology. TCS provides communication and wi-fi connectivity to emergency response vehicles when in a no-coverage cellular zone. Both these innovations marked milestones in the internal innovation trajectory of TTR.

Since the beginning, TTR has valued collaborating with their customers to deliver customer driven innovations and customisations in their products and solutions. The R&D manager, Ken, emphasised the importance of their relationships with customers as a valuable resource for their innovation process.

> "Our most important IP is our customer knowledge. Our relationships are Abiding, not simply a case of purchase. … We are involved in a business problem. … The more you understand the customer, the stickier the relationship. We become mutually dependable" (Ken, personal communication, August 11, 2017)

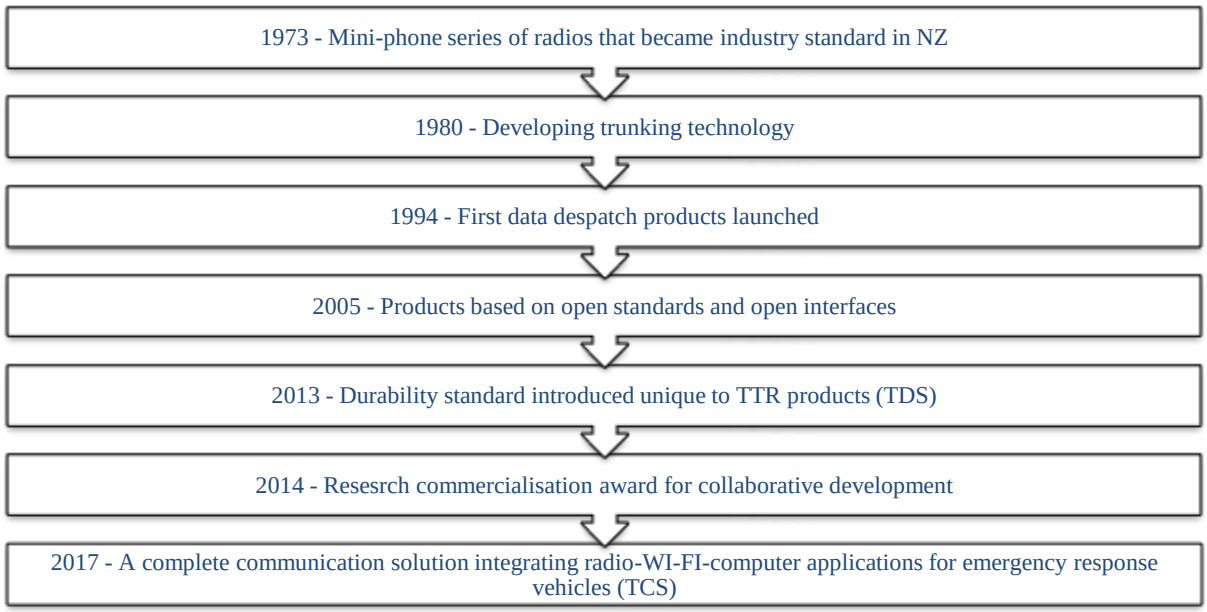

Figure 4-6: Innovation milestones at TTR

[71] A pseudo-acronym
[72] A pseudo-acronym

Another long-standing collaborative partnership for TTR is with the local university. In partnership with a subsidiary, TTR has invested in creating a research group within the university, which conducts valuable basic and applied research for the company. TTR plays a key role in mentoring and supervising students who undertake the research. They view the university as a key resource for new knowledge, and in turn provide them with access to the company's technology and strategies.

> "University collaboration is mainly to have a flow of knowledge into the company" (Ken, personal communication, August 11, 2017)

Marking the success of collaborations between the firm and the university, TTR won an award for excellence in research commercialisation in recognition of not only expanding their own business and capabilities, but also helping upscale the capabilities of university students to achieve excellence in research and commercial expertise[73].

With the appointment of a new CTO, Larry, TTR has opened up their innovation process even more, increasing their involvement in collaborations for product, firmware and software development innovations. Even though the partnerships operate under strict non-disclosure agreements (NDAs) and other legal contracts governing value sharing and addressing ownership issues, TTR has found that these partnerships are gradually making them much more open and sharing of knowledge than previously.

> "We used to do things our own way for a long time. But the technology has moved way forward. The partnerships help us to catch up with the world tech-wise and keep updated." (Larry, personal communication, September 27, 2017)

> "TTR is really good at what it does – building radios. It has been for the last 50 years. But the technology world has moved on. Keeping up with it is very important. So we connect with the world to stay connected to the changes. We use the phrase 'stealing with pride' [*meaning they use the knowledge in the public domain for internal innovations*]. Our partners help keep up as well." (Larry, personal communication, September 27, 2017)

TTR recently entered into a partnership with a Chinese manufacturer for Original Equipment Manufacturing (OEM). The Chinese manufacturer will be producing the same hardware that TTR produces in NZ, but at a lower cost. OEM is the result of an innovative process which TTR believes has been a good learning opportunity for the company because the resulting lower cost hardware is not solely due to the relatively lower labour costs in China, but also other efficiency factors. For their part, TTR is sharing internal knowledge on communications

[73] Information from third party news items.

protocols with their Chinese counterpart to make OEM products operable under similar technological standards as in other markets.

Another significant milestone in collaborative innovation for TTR is its ongoing partnerships with an Australian firm and a UK firm to develop software applications that run on TTR manufactured communications equipment. This requires TTR to share the application programming interfaces (APIs) with their partners.

> "We have our Hardware, and our software. Then we have the APIs that help communication between applications. By making the API open, anyone can develop an application that can communicate with our products." (Larry, personal communication, September 27, 2017)

This is similar to the app development process used by independent developers for iOS and Android mobile platforms. The APIs are the communications technology that operates between software applications and the operating system of the equipment. By making the APIs open, TTR can allow any user to develop applications to run on TTR equipment to suit their requirements. A similar real-world example is when operating systems developers opened up their APIs, allowing third party users to develop applications to run on the OS system (E.g. iOS, Android). However, opening up their APIs is still in the experimental stage at TTR, and so far, the APIs have only been made open to the said partners.

> "We are trying to make our APIs public. With sharing the APIs, our plan is to create a partner eco-system. So that anyone can use them. The development of this is in progress and will go live soon. But we are yet to decide if this will be publicly open for free or open to a fee-paying member." (Larry, personal communication, September 27, 2017)

Furthermore, TTR partnered with a US firm to develop a system able to convert smart phones into mobile radios ('Walkie-talkies'). Combining Push-to-talk-over-cellular-technology (PTToC) and satellite communications technologies with TTR's existing radio communications technology has enabled an ordinary smartphone to be converted to a mobile radio with the push of a button. The free exchange of PTToC (from the US firm) and land mobile radio (LMR) communication technology[74] (from TTR) between the parties led to the development of this unified product, which is branded as TTR. The innovation subsequently contributed to the development of TCS, another milestone for TTR.

[74] LMR – Land Mobile Radio system is a wireless communications system used by terrestrial users in vehicles or on foot. More information can be found at www.anritsu.com/en-US/test-measurement/technologies/land-mobile-radio.

Table 4-9: Overview of TTR projects

Project	Innovation process	Purpose	Knowledge outflow from TTR	Outcome
OEM	Collaboration with a manufacturer	To develop a cost-effective manufacturing process	Communications protocols developed and used in TTR	A low-cost product operating on similar technical specifications as the original TTR product
Open API (Ongoing)	Collaboration with a UK and an Australian firm	Trialling the possibility of making the API platform open to allow third party application development	The technology, source code and the protocols required to use the APIs	Potentially, increased device sales and creating industry standards for mobile radios
PTToC	Collaboration with a US firm specialising in software and hardware development in the cellular communications field	To develop a solution to convert any smartphone into a mobile radio during emergency situations when the cellular network is inaccessible	LMR technology	A mutually beneficial product that can be integrated with multiple radio networks. Ultimately integrated into TCS–the complete solution for emergency vehicles.

TTR has many other existing collaborations with resellers in multiple countries. Although innovations are not an outcome of these partnerships, a certain amount of technical knowledge is shared by TTR with the reselling partners to enable them to position the products in their respective markets. Among these is a unique partnership with a US reseller that happens to be a direct competitor of TTR. Even though there are overlapping products between the partners, the contractual agreement explicitly specifies 'whose products are which' (Larry, personal Communication, September 27, 2017).

4.6.3 Revealing in TTR[75]

Since its establishment, TTR has had a relatively closed innovation process where the major incremental and radical innovations take place in-house. While they undertook collaborative research with the local university, it was initially directed at developing futuristic technologies, outside and beyond the current innovation trajectories of TTR (Ken, personal communications, August 11, 2017). However, during the last 10 to 15 years, TTR has shifted from a product-oriented business model to a solution oriented business model, where the value for the company lies in the overall architecture of a communications solution, rather than specific equipment.

[75] Information through interviews, news articles and field notes.

Furthermore, with the rapid advancements in the fields of information technology and mobile communications, TTR has recognised that collaborations are needed to keep up with the pace and gain access to knowledge they do not possess in-house. TTR realises that restricting R&D to in-house developments only is both costly and time consuming.

> "We used to do things our own way for a long time. But the technology has moved way forward. The partnerships help us to catch up with the world tech-wise and keep updated." (Larry, personal communication, September 27, 2017)

The shift from closed innovation to opening up the process seems to have created some challenges for TTR. Speaking about collaborations and the resultant requirement for knowledge sharing between parties, Larry stated that gaining support from TTR engineers to participate in the PTToC project had been challenging. They had to resort to using the R&D team to initiate the project, and they were "not the traditional resources to get started" he added (2017).

Another challenge for TTR is balancing the different commercial interests within collaborations to the mutual benefit of all parties. Since not all firms that collaborate with TTR share the same corporate strategy, requirements or strengths, they have different expectations from the collaboration. However, as Larry explained, this issue can be resolved through negotiation.

> "Our commercial interests are not always the same. But negotiations always make sure we find the balance. Commercial motivations are needed to make the partnership successful and not take advantage. It's all about working together to make money at the end." (Larry, personal communication, September 27, 2017)

Communication between parties is another area that TTR finds challenging, especially in collaborations involving multilingual or multicultural settings. Larry mentioned that cultural and language barriers can sometimes distort message delivery between parties.

> "We would share the time line, go through it with them and they [other party] say yes to completing in one month, and in one month, they are behind. Again, if you ask them how long they need, the translator would have a long discussion with them, and translate to us saying one week. But when asked what the long discussion was about, they were saying if all goes to plan and if there are no problems one week is good." … "They would always say yes because saying no is considered impolite." (Larry, personal communication, September 27, 2017)

However, it was not clear whether language or cultural differences affected knowledge sharing between the parties.

While the interviewees emphasised that these collaborations are strictly governed by non-disclosure agreements (NDAs) and contracts, they further stated that they have benefited TTR

through providing access to knowledge that is beyond the scope of the TTR technology domain. For example, the partnership set up to develop the capability for enabling a smartphone to turn into a mobile radio combines radio communication equipment and technology from TTR with PTToC and satellite communication technologies from their partners.

> "The PTToC belongs to a firm in California. They gave us the PTToC free we gave them the LMR free and finally the complete technology will be licensed to others." (Larry, personal communication, September 27, 2017)

Due to contractual agreements and a documented NDA process, TTR has become relatively more open to their partners. Even their long-standing relationship with the local university has evolved from researching futuristic innovations that the entire industry was aiming to address, to include more applied research that helps TTR to model and design solutions for clients. The R&D manager explained that previously the contracts and agreements were specific and customised to individual staff members of the university. However, now the university has an overarching NDA in place that simplifies the contractual partnership. This has been made possible by the trust and understanding that TTR and the university have built over their 20+ years of partnership.

> "When we work with PhDs, master's students or Uni staff, we allow them to publish but we filter what is shared. (E.g. remove context of the technologies). We also make sure the critical company relevant knowledge is patented if they are being published. If the company is paying for the research and mentoring the researcher, the company owns the IP for the research. However, this is flexible if the knowledge is not 100% relevant to the company." (Ken, personal communication, September 27, 2017)

The majority of the innovative knowledge developed by TTR is in the form of patents. The IP policy provides six ways to patent based on the strategic direction of an innovation (R&D manager, personal communications, August 11, 2017; June 20, 2018), namely: Feature protection, Counter licensing, Exploitation (to sell the patent), Control licensing, Collaboration (as a means of creating business partnerships), and Defensive publications (to prevent a competitor from claiming ownership). While patents necessarily restrict the use of the knowledge they contain in commercial contexts, all patents are in the public domain and therefore accessible by the public for learning purposes.

> "Patents are not always for the money. They are used to position the company. They are useful in partnering with other companies, Negotiations, etc. especially useful to create standards. (e.g. if the only company that makes a certain product is us, patenting it is useful to make it a standard and subsequently generate royalties)." (Ken, personal communication, August 11, 2017)

Ken pointed out that besides their technical and engineering knowledge, TTR's most valuable IP is their accumulated knowledge of the customers. Due to viewing each client as a long-term partner (even though not all customer relationships contribute to innovation), TTR accumulates

knowledge on how their products are used, customised and modified. Such knowledge becomes input for incremental innovation and customisation. In R&D collaborations such as API sharing, PTToC, and also university research, this knowledge from customers, along with the technical knowledge TTR shares with their partners, is vital to the design and implementation of products and solutions.

> "We collaborated once with an analytical utilities company to find a solution for worker safety. We listened to their problem and developed a prototype. They used the porotypes, tested them and gave feedback. After several repetitions, now it has turned into a product." (Ken, personal communication, August 11, 2017)

The main reason to collaborate is the possibility of accessing new knowledge. In particular, the three projects discussed in section 5.2, OEM, Open API and the PPToC, gave TTR access to new technological expertise that was useful for internal innovations. The Open API project will allow TTR to set standards in communications technology, even if the APIs are shared under privileged access to a restricted few rather than as open source.

The university collaborations have provided TTR with a platform for experimenting with new ideas and approaches to problem solving.

> "For example, University helped in modelling how our products can be scaled and size of designs, how many terminals are needed, etc." (Ken, personal communication, August 11, 2017)

Ken further stated that the research conducted in collaboration with the university has allowed them to explore futuristic solutions to common problems faced by the industry. Furthermore, it provides a pathway for recruiting employees who are already familiar with the work, culture and technological capabilities of TTR.

> "We recruit from the university. Quality of the people is important." (Ken, personal communication, August 11, 2017)

The collaborations with suppliers and resellers provide access to new markets. Even though such collaborations are not aimed at developing innovations, they require significant knowledge output from TTR to enable the partners to position, service and market TTR products. It seems that such partnerships further mitigate the competition in certain markets through joining with competitors to sell a single solution rather than individual products[76].

[76] From press release announcing TTR's partnership with a market leader in an international market, August 01, 2016. Viewed on June 15, 2018

4.6.3.1 Revealing process and activities

Among the strategic options for revealing presented at the beginning of the chapter in Table 4-14, TTR mostly uses collaborations and the patenting process. Their IP policy provides guidance on defining appropriate protective layers for the knowledge components based on their potential reusability by the firm. As explained previously, the policy outlines six categories of patents. Patenting in TTR is not always for revenue generation. Accordingly, the categorisation of patents by purpose forces the firm to develop a strategic vision around the knowledge component before filing.

Table 4-10: Strategic actions used in TTR

Action	Purpose	Evidence
IP policy	To define how the knowledge is to be 'protected'	"We have an IP policy in place which defines what to do for: Feature protection; Counter licensing; Exploitation; Control license; Collaboration; Defensive publications. The policy has guidelines to decide what protection to use." (Ken, personal communication, August 11, 2017)
Patenting as a public disclosure method	To claim ownership to the knowledge, reputation and credibility	"We protect our IP through types of patenting or keeping it a trade secret. If the knowledge is needed to go public or if the knowledge is critical, we patent. If not we keep it a secret." (Ken, personal communication, August 11, 2017)
Review of content before publication	To avoid unintentional knowledge leakage	"When we work with PhD, master's students or uni staff, we allow them to publish but we filter what is shared. (E.g. remove context of the technologies). We also make sure the critical company relevant knowledge is patented if it is being published." (Ken, personal communication, August 11, 2017)
Use of design thinking practices	Understanding the partnerships; To avoid resource wastage.	"Different relationships demand different strategies." (Ken, personal communication, August 11, 2017) "We avoid R&D wastage by involving design thinking in these collaborations." (Ken, personal communication, August 11, 2017)

TTR see patenting as an alternative to open disclosure. Due to the knowledge protective nature of the firm, if TTR requires knowledge to be publicly disclosed, they seek to patent, which gives them ownership in exchange for placing the knowledge in the public domain. Disclosing knowledge is important for the firm's credibility, reputation and for standardising purposes. Therefore, patents meet this requirement, but with the addition of IP rights.

Another strategy TTR use with regard to revealing activities is to review the content of university publications. Even though, as Ken pointed out, the research activities are not closely related to the core business of TTR, publications are still reviewed to ensure de-

contextualisation of knowledge to prevent reusability, or that knowledge is protected via necessary means before publication.

Finally, the use of design thinking (DT) approaches ensures that TTR invests in sharing or deploying only the necessary knowledge and resources in a collaboration. Especially in partnerships with clients to develop solutions, the DT approach ensures that the process begins by understanding the requirements of the client[77]. TTR can define the level of knowledge required to be shared based on their modularisation of internal knowledge.

4.7 Chapter summary

This chapter presented the case findings for revealing across five innovative firms in New Zealand to show a broad spectrum, from extreme openness to highly restrictive approaches (summarised in Appendix E). Even though each case displays specific attributes relevant to the form of revealing practiced, there are some commonalities across the five cases as well. Some common aspects include the prominent influence of organisational characteristics in the revealing process, the existence of modularity as a key aspect, and the role of firm capabilities. Each firm uses specific strategies to formulate the revealing approach based on their requirements. Furthermore, it is interesting to note that all firms understood revealing, or as it is more commonly termed, 'open sharing', as creating public good, as opposed to its definition in Open Innovation. These findings will be further analysed in Chapter 5.

[77] Interview with Ken on August 11, 2017. He explained the process they use with visual aids on his computer.

CHAPTER 5 ANALYSING THE FINDINGS

5.1 Introduction

This chapter presents the analysis and findings from the empirical data gathered across the five case firms introduced in the preceding chapter to address the research question. Recapping from the first chapter, the main research question (RQ) addressed by this study is:

Why, and how do firms implement revealing?

The main objective of the thesis is to shed light on the variation in revealing implementation by developing a framework that integrates related firm-level factors and their interplay in revealing activities in multiple firm contexts.

Figure 2-6 (repeated from chapter 2) presents the conceptual framework that guided the empirical work. The framework constructs were identified through a review of extant scholarly work on revealing, and related theoretical perspectives. The remainder of the chapter is organised based on these constructs and their associations with the revealing behaviours.

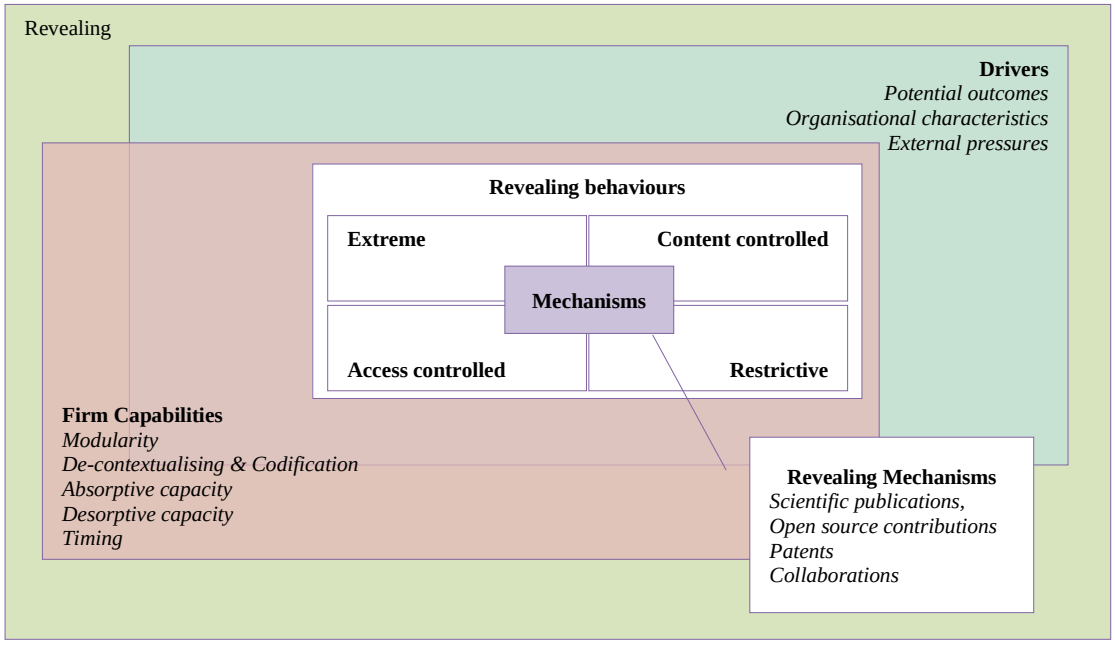

Figure 2-6 (repeated): Conceptual framework

First, the analysis and findings for the four revealing behaviours and corresponding mechanisms are presented. This is followed by the findings on the firm-level factors identified through the empirical study and their association with revealing behaviours. The chapter concludes with a discussion of the implications regarding the research question and a clearer conceptualisation of revealing implementation is presented.

5.2 Revealing behaviours and the revealing mechanisms

This section presents the findings on the revealing behaviours and corresponding revealing mechanisms identified through the empirical work. The study investigated five case firms that implement revealing practices. The case descriptions from Chapter 4 indicate that the five case firms exhibit different revealing behaviours, which can be differentiated based on selectivity in the knowledge content revealed and the access allowed by the firm to the revealed knowledge (Table 5-1). This is consistent with the two dimensions that differentiate the revealing behaviours, as proposed in Chapter 2. The rest of this section discusses the revealing behaviours and mechanisms used in each firm and the supporting evidence.

Table 5-1: Revealing in the case firms

Case firm	Content revealed	Access to revealed knowledge	Mechanisms
EVD	No deliberate restrictions as trade secrets. But some unrevealed knowledge due to non-consent by collaborators.	No restrictions. Takes active effort to make the knowledge accessible by a wider audience.	Publications (incl. technical, practitioner, internet based) Training workshops and conference presentations; Open-source databases
LMO	No deliberate restrictions as trade secrets. But some unrevealed knowledge due to resource constraints.	No restrictions. Takes active effort to make the knowledge accessible and widely re-useable.	Open source contribution Publications (internet based) Workshops & conferences (incl. online discussion forums)
SMX	Process level knowledge is shared openly. Some restrictions apply to the product related knowledge modules.	Both restrictive privileged access and public access depending on the knowledge modules.	Scientific publications and conferences; Patents; Collaborations incl. visiting facilities, exchange of personnel
RQL	Significant amount of trade secrets and patents. Uses the IP catalogue system to identify knowledge to reveal without restrictions. Reviews knowledge before scientific publishing.	Revealing internal knowledge is restricted to partners except for patented knowledge. University research outputs are not restricted when revealed.	Restrictive partnerships; Scientific publications Patents Collaborations incl. visiting partner facilities, material exchange
TTR	Significant amount of trade secrets and restrictive disclosure through patents. University research is actively regulated to produce publishable knowledge	Revealing internal knowledge is restricted to partners except the patented knowledge. University research outputs are not restricted when revealed.	Collaborative development; Scientific publications Patents

The revealing behaviours for each firms was identified through the participants' description of knowledge flows and the analysis of revealing mechanisms. The case description provide insights to the key decisions and actions each firm take when revealing. Participants descriptions of tasks, actions, routines or decisions that indicate purposive selectivity or none-selectivity in what to reveal (content) and who access the knowledge once revealed (access) indicates the restrictive/unrestrictive nature of the both dimensions. These findings were triangulated with the revealing mechanisms of firms to determine the revealing behaviours. For example, statements such as "We want to turn the company inside out and show everybody how it works" (EVD) would indicate that the firm is not restricting what they reveal. Hence, no restrictions are imposed on the content by the firm. This is further evidenced by the process EVD use to articulate the knowledge described in chapter 5. Even though there are measures to scope content, the firm is not deliberately restricting the content in order appropriate them. The following section explains the revealing behaviours for each firm.

EVD and LMO describe themselves as 'mission-led' to be open and create public good as an outcome of their revealing processes. Comparative to the other three firms, both EVD and LMO can be classified as extremely open in their revealing activities. Neither company deliberately restricts access to their knowledge, and in fact both go into great lengths to ensure their knowledge reaches as wide an audience as possible. The specific tactics used in their revealing processes show that the main objective is to share the knowledge so that it will be re-used in the intended manner.

However, even these two firms display varying levels of openness. For example, in addition to the knowledge created internally, EVD aims to share all operational information including their payroll, despite being a privately-owned small enterprise that is not required to disclose such operational level information. While not directly relevant to their revealing activities and so not as significant as knowledge affecting their competitive advantage, sharing operational information further strengthens their effort toward 'being open' in their mission to create impact.

In contrast, the 'openness' of LMO does not extend to financial and other operational details, apart from their management style. Knowledge relevant to the management style of the firm is directly linked to their core product, which is the collaborative software. Therefore, by following their own guidelines for organising without authority, LMO is essentially putting into practice the ideology on which their software is founded.

> We are creating a new wave, … the sharing economy. This idea of different ways of organising for work, navigating that has personal benefits. Beside the satisfaction of working, feeling like the benefit of being open is that we get there together better. So, a benefit is hopefully LMO is enabling lots of groups. Because we are open and free, other groups that need it who are also trying to shape the world in greater ways. (Halle, personal communication, September 16, 2016)

SMX, the third case firm is mandated by the government to openly share internal knowledge. Due to the nature of their work, a certain level of confidentiality and privacy around the relevant information must be maintained. Therefore, they cannot be as extremely open with revealing as EVD or LMO. However, SMX still reveals extensive knowledge corresponding to the processes for scientific analyses, the algorithms used in the analytical tools, forensic research methods, and protocols. Even though their openness is legally mandated, SMX is given the autonomy to retain certain knowledge components deemed important for commercial appropriation, or complete protection under reasonable circumstances. Statements from the SMX interviewees show they strive to find a 'balance in private and public' knowledge.

> When we do bid in for research funding there's always the requirement of how we transfer that into learning, how we share the knowledge. All the research funding applications have an implementation pathway that is required of it. Within that we have to show how we transfer that IP." (Steve, personal communication, September 19, 2017)

However, much of the 'private knowledge' referred to is in the form of patents rather than trade secrets, which means the knowledge is still in the public domain.

SMX further conducts a significant amount of collaborative research and development. Therefore, the knowledge that is not publicly shared through publishing in peer-reviewed journals is nevertheless shared with their partners in some instances. For example, in the DIP development process, the firmware and source codes have not been published for public access. Only persons authorised by all parties can access this layer of knowledge. The users of DIP software are granted privileged access to a community intranet that comprises another layer of knowledge, for example guidance on how to respond to court questions relevant to the software. This is free but not available to the public. Hence, SMX seems to be exercising restrictiveness as well as openness in both content and access, depending on the circumstances and various knowledge levels. This was evident in most projects SMX shared details about.

RQL and TTR are more restrictive in their revealing activities. They both reveal knowledge in formal partnerships which are governed by NDAs. Even though both firms engage in scientific publishing, they go through internal review processes to avoid sharing knowledge that could negatively impact the value captured from innovations.

RQL and TTR seem to have a broadly similar revealing profile, but some observations provide insight into their differences. While RQL is protective of their knowledge, they have made efforts to allow some flexibility around what content can be revealed. They have tailored an IP catalogue (sometimes called the IP strategy) as well as cataloguing guidelines, which shows that the company is purposively open to renegotiating their restrictions based on the situation. Further, although confidential documents, they were willing to share them for the purposes of this research.

TTR on the other hand, are more restrictive in the revealing activities. For example, TTR actively regulate the research collaborations with universities – their main source of publications – to focus on solving futuristic problems that the entire industry faces as a whole.

> We will see if it is critical to our products. If so, we won't allow it to be published. We usually won't put them in a position that they would come up with something that is critical to our products. (Ken, personal communication, August 11, 2018)

Furthermore, TTR did not present any evidence of having knowledge they identified as 'safe to disclose'.

> We protect our IP in ways of Patenting or keeping it a trade secret. If the knowledge is needed to go public or if the knowledge is critical, we patent. If not, we keep it a secret. (Ken, personal communication, August 11, 2018)

The findings show that at the project level, apart from the extremely open firms – EVD and LMO, the other firms display multiple revealing profiles. When aggregated to the organisational level and taking into consideration the nature of the main revealing activities, the firms each exhibit prominent revealing behaviours as illustrated in Table 5-2. Other behaviours identified for each firm encompass revealing activities that are given less prominence by the respective firm. Even though this is a reductionistic view of their revealing behaviours in practice, identifying the specific revealing behaviours of each firms is a necessary first-step in understanding the application of the phenomenon (see Suddaby, 2010).

Table 5-2: Revealing behaviours in firms

Case firms	***Access to the knowledge revealed***		***Amount of knowledge revealed***		**Prominent revealing behaviour/s**	**Other revealing behaviour/s**
	Unres.	*Res.*	*N-sel.*	*Sel.*		
EVD	✓		✓		Extreme	-
LMO	✓		✓		Extreme	-
SMX	✓	✓	✓	✓	Content-controlled; Access-controlled	-
RQL	✓	✓		✓	Restrictive	Content-controlled
TTR	✓	✓		✓	Restrictive	Content-controlled

In summary, EVD and LMO engage in *extreme* revealing where neither the amount of knowledge nor the access to it are restricted. RQL and TTR engage in *restrictive* revealing where both amount of knowledge and access are restricted. SMX is a unique case among the firms, as they exhibit both *access-controlled* and *content-controlled* revealing almost equally, but at different layers.

5.3 Influence of firm-level factors on revealing

This section presents the analysis and findings for the firm-level factors and their interplay with the revealing behaviours. Table 5-3 illustrates the data structure in a tabular form, as developed from the coding and analysis process for the case data (e.g. see Schussler et al., 2014). The first order terms were derived based on a coding structure guided by the research questions, the conceptual framework, and in-vivo codes. These were then grouped and aggregated into the second order and third order respectively following a categorising and abstraction process (Miles et al., 2014; Spiggle, 1994).

The conceptual framework presents two firm-level factors relevant to revealing: *drivers to reveal* and *revealing capabilities*. These framework constructs guided the coding process to identify drivers and capabilities across the case firms. The coding process further allowed for new concepts to emerge through the in-vivo coding and annotations, which led to the derivation of *strategic actions* relevant to the revealing implementation. Strategic actions are specific activities that firms conduct to manage the revealing implementation. These activities further explain how the firms implemented revealing.

Table 5-3: Data structure[78]

Conceptual framework	**First order**	**Second order**	**Third order**
Drivers (Data sources = 35+)	Openness being a core founding value of the firm	Ideologically driven revealing	Altruistically driven revealing
	Revealing to create social/environmental impact		
	Establish operational best practices within the industry	Revealing to induce industry advancement	
	Revealing ongoing work to avoid repetitive R&D		
	Desire to fill technical knowledge gaps in the industry		

[78] Legend: text in *italics* represent items with inconsistent support across cases; text in **bold** represent the emerging themes.

Conceptual framework	**First order**	**Second order**	**Third order**
	To source knowledge, capabilities or market access	Revealing for internal advancement	Goal driven revealing
	As an image building exercise for reputation and validation		
	As a defensive strategy to claim ownership of knowledge		
	Create delayed revenue models		
Capabilities (Data sources = 20+)	Academic training to codify knowledge	Codification of knowledge	Capabilities to create content suitable for revealing
	Simplifying complex knowledge for a general audience		
	Ability to use a variety of platforms to communicate the knowledge	Presentation of knowledge	
	Having internal IP management protocols that define disclosable knowledge	Making the knowledge selectable	Capabilities to strategically manage the revealing process
	Ability to modularise knowledge		
	Identifying risk-reward balance in revealing activities	**Managing risks of oversharing**	
	Identifying, evaluating and efforts to understand partners		
	Establish contracts and guidelines for revealing through prior experience		
	Having a long-term action plan for the revealing *activities*	**Prudent management of the revealing activities**	
	Adjusting revealing *techniques based on timely requirements*		
	Contingently adjusting the disclosure rules for knowledge modules		
Emerged from the coding process			
Strategic actions (Data sources = 20+)	Conducting internal reviews to avoid disclosing critical knowledge	Internal knowledge preparation	Active selectivity and management for control
	Classification of knowledge for effective identification and management		
	Use of formal and informal guidelines to conduct initial talks with partners	Diligent collaboration management	
	Use of agreements and trust building during collaborations		
	Positioning knowledge in the appropriate user domain	Enhancing reach	Active dissemination for reuse
	Timing revealing activities with relevant external events for higher awareness		
	Peer validation of knowledge before revealing	Enhancing reusability	
	Presentation of knowledge for optimum reuse		

The typographical emphasis is used to indicate emerging themes and inconsistent data categories (cf. Hargadon & Sutton, 1997). Bold typeface indicates the categories and themes that emerged from the data. The items in italic typeface indicate first-order items that appear inconsistently in data, e.g. appear in fewer firms, but have a strong presence in the respective

firm/s. Since one of the objectives of the study is to explore revealing in firms and draw connections between the factors and the revealing behaviours, these items are included in the analysis. Even though their presence is inconsistent across the five firms, they provide the necessary nuanced insights to explain the specificities of implementing revealing behaviour/s in the firms. The analysis and findings are further explained in the following sections.

5.3.1 Drivers of revealing and revealing behaviours

The drivers explain why firms reveal. As outlined in the conceptual framework, potential outcomes, firm characteristics and external pressures were used to guide the coding process. In-vivo coding did not identify any new driver categories. This section looks at the drivers identified across the five cases to understand how they lead to the specific revealing profiles.

The nine first-order categories of motivators identified through coding led to the three second-order groups, namely: (a) ideologically driven, (b) for industry advancement, and (c) for internal advancements. Table 5-4 presents the examples of representative data for each data category. Two aggregated themes were derived from these – *altruistically driven* revealing and *goal driven* revealing.

Table 5-4: Drivers of revealing – representative data

First order	Representative data
Altruistic drivers	
Ideologically driven revealing	
Openness being a core founding value of the firm	"We did all this research and it is kind of crazy to lock them away in a cupboard when other people can learn from what we are doing and copy us." (Ben, personal communication, October 19, 2016) "The transparency stuff that we are trying to implement by the end of the year which is kind of quickly coming around, we want to turn the company inside out and show everybody how it works. Part of the reason for that is to show people how a small business works on sustainability" (Andy, personal communication, October 19, 2016) "Open encourages us to be about our values…We are open because we want to see other people adopt our values. So, we have to be open about them and we have to have values that are worthwhile to be open." (Isaac, personal communication, September 16, 2016) "Our org being open started off with every Friday we would have an open meeting. And anyone could come along. That was called an *all hands meeting*. Anyone from the community can come along and we would try to openly discuss everything about the business. From that is how we formed our original form of members and the cooperative. The embryonic stage of LMO was an open Friday meeting. [Thinking for a few seconds]." (Dan, personal communication, September 16, 2016)

First order	Representative data
Revealing to create social/environmental impact	"We are committed to impacting the world" (Andy, personal communication, October 14, 2016) "They [refers to the organisational aspects] go up against our mutual commitment to maximise our positive social impact and to be just be coherent with our ethics that our ethical coherence is non-negotiable." (Dan, personal communication, September 16, 2016) "We are creating a new wave, you know, I don't know all the terms, but a sharing economy. This idea of different ways of organising for work; navigating that has personal benefits. Beside the satisfaction of working, feeling like the benefit of being open is that we get there together better. So, a benefit is hopefully LMO is enabling lots of groups; Because we are open and free, other groups that need it who are also trying to shape the world in greater ways." (Halle, personal communication, September 16, 2016)
Revealing to induce industry advancement	
Establish operational best practices in the industry	"The motivation was wanting to see change [in the building industry]. When you knew there is a problem we pressure to find a way to solve the problem. Let's do this and see what we can do if we shared these things. If we shared this information, can that make people to understand easier what is possible, can that inspire the people to do something or will it make easier for them to do it. Basically, that was the motivation." (Ben, personal communication, October 19, 2016) "So, a huge part of the company is about disseminating knowledge and teaching people what to do. Which I think is where our fundamental drive of being open and sharing stuff comes from. Because the whole mission of the company is to see improvement in the industry." (Andy, personal communication, October 14, 2016) "For instance, we were to help Customs to identify requirements around examining an item – e.g. a package in the mail – that may have suspicious substance in them. Sometimes those substances come to us for an analysis. When they do, we would supply a series of forensic protocols to give a reliable result. All that work is kind of pointless at some time at the start of it when the item was retrieved, they were collected by another agency and there was some breakdown in reliability or quality that means the total output that goes to court can be made unreliable… that helps them do a better job that potentially follows through to some work for us. It also helps to protect the overall quality of the output for justice." (Mike, personal communication, August 09, 2017)
Revealing ongoing work to avoid repetitive R&D	"Lots of people are doing lots of similar things in the world. Because it is a connected world. I think, I mean, we are not doing anything absolutely new or anything. So, I think lots of people are doing similar things and so starting from scratch seems unnecessary sometimes. If you are able to share the information you are creating, a community of likeminded people. You are helping others who are also helping you to move forward I guess." (Cathy, personal communication, October 25, 2016) "It's the fundamental premise that underpins a lot of the concepts we're working on," adds [Cofounder]. "If we can make this information as readily available as possible, it provides a [basis] for others to build and improve upon, rather than having to start from scratch." (EVD, document data, 2016) "We also publish because we want to get those insights out to the community so that people can benefit from them. For example, we've done a particular piece of work where we have developed a new way of capturing and presenting the crime scene, if we publish something about that then, it gives us reputation in the field and shows the kind of org. we are. But also allows others to copy and take that knowledge and improve on it." (Mike, personal communications, August 09, 2017)

First order	Representative data
Desire to fill technical knowledge gaps in the industry	"The problem is that people often don't know that there's a different way of building. For a long time, it's been a case of you get what you're given. What we're trying to do is empower people to understand and ask for the things that are important to them. The sector has all the technology and design and construction methods, but until people start asking [for sustainability features] it won't deliver them. So, a big thing for us is about giving people the language to ask for these things." (EVD, document data, 2016) "We see a way for us to help share our experience on what works, what the expectations are [about scientific methods of forensic analysis]." (Mike, personal communication, August 09, 2017) "For instance, we were to help customs to identify requirements around examining an item – e.g. a package in the mail – that may have suspicious substance in them. Sometimes those substances come to us for an analysis. When they do, we would supply a series of forensic protocols to give a reliable result. All that work is kind of pointless at some time at the start of it when the item was retrieved, they were collected by another agency and there was some breakdown in reliability or quality that means the total output that goes to court can be made unreliable…that helps them do a better job that potentially follows through to some work for us. It also helps to protect the overall quality of the output for justice." (Mike, personal communication, August 09, 2017)
Goal-oriented motivators	
For internal advancement	
To source knowledge, access to markets or capabilities	"We got some information around the market opportunity as they [BT] saw it because it was an opportunity we were also interested in. we got some learning out of that. It was a data point that help understand the market better." (Vince, personal communication, June 29, 2017) "University collaboration is mainly to have a flow of knowledge into the company" (Ken, personal communication, August 11, 2017) "The product and solution partners are involved in providing the capabilities that we don't have." (Ken, personal communication, August 11, 2017) "It's this connectivity that provides us with access to knowledge and expertise that will allow us to continue to innovate and evolve to meet the needs of our clients." (TTR, document data, 2013) "We used to do things our own way for a long time. But the technology has moved way forward. The partnerships help us to catch up with the world tech-wise and keep updated." (Larry, September 27, 2017)
As an image building exercise for reputation and validation	"Sometimes we publish because it's important to the individual to develop a publication record. That is important for someone for monitoring their performance and being rewarded and recognised for developing their career. It is also really important when we want people setting up with a track record to go for subsequent funding, for example, the MB funding applications require a principal investigator who is leading the work, and what's their track record. How do we know this person got the capability to this, who have they worked with in the past, and what kind of experience do they have? A publication record is a really good way to do that." (Mike, personal communication, August 09, 2017) "We put very high expectations on ourselves around the reliability of the evidence and the ease in which someone could understand it and trust what comes out. It's an opportunity say, 'We think we are good at this and we can help'; so partly its reputation." (Mike, personal communication, August 09, 2017)

First order	Representative data
As a defensive strategy	"We patent where we can – novelty and other patenting criteria. Then we look at if it is something that is very hard to keep a secret. If so, it is better to patent it; because it is going to be disclosed anyway when you put the product in the field." (Vince, personal communication, June 29, 2017) "We have an IP policy in place which defines what to do when: Protecting a feature (e.g. filing a patent to protect your unique feature), Counter Licensing, Exploitation (e.g. selling IP), Collaboration (i.e. using patents to create a business relationship), and then *simply defensive publication* (i.e. filing a patent to prevent a competitor from capturing that IP, an alternative is simply to publish openly)." (Ken, personal communication, June 20, 2018) "We protect our IP in ways of Patenting or keeping it a trade secret. If the knowledge is needed to go public or if the knowledge is critical, we patent. If not, we keep it a secret." (Ken, personal communication, June 20, 2018)
Create delayed revenue models	"We have to think about it in a context of knowledge flows in both ways. Both in and out. In terms of knowledge flowing out of SMX, you have things like enhanced collaboration and reputation. You've also got revenue flows from sale of IP, royalties, research collaborations." (Patric, September 13, 2017) "The first thing is money – revenue. It [knowledge sharing] all comes to it at the end." (Ken, personal communication, August 11, 2017) "[partnership with BT] But we didn't get the huge benefit that was a possibility i.e. they would purchase 1000s of these devices. *It was the motivation* that drew us into the collaboration but did not happen. So, learning + some commercial benefits." (Vince, personal communication, June 29, 2017) All the partnerships in RQL indicate sales revenue at the end (e.g. given in Chapter 5).

Altruistically driven revealing focuses on achieving greater good. The first-order categories in this group present stimuli for revealing that are generated by the aim of achieving goals that transcend the need to create benefits for the firm. Items under ideological drivers represent characteristics in the firms that influence revealing activities. While not consistent across all five firms, it is ideological drivers that provide two firms with their strong motivation to reveal. The two case firms in this study motivated by an ethos that favours openness and transparency believe that by doing so, they can make a change in the industry. Openness is a founding value of these two firms. These firms are 'mission-led' to 'make an impact' by being open and transparent. Responding to the questions on why they reveal, they both highlighted the 'impact' they wish to make through such efforts. They feel that being open and revealing is their 'natural course', rather than an option they have deliberately chosen for their firms.

> I think it's not like, that we sit back with a whiteboard with pros and cons of open and closed, it's [openness] just a reflection of our values and our culture. (Dan, personal communication, September 16, 2016)

This is closely connected with the need to create greater impact socially or environmentally. A key reason behind EVD's and LMO's revealing activities is their belief in the need to change how the industry and society at large operate. For example, EVD reveals lessons learnt from

their projects in an attempt to encourage the community to build sustainable buildings. They identified the need to educate consumers as well as the construction industry on the possibility of constructing better buildings. They believe this will not only encourage the industry to build sustainable buildings, but further, create a greater environmental impact by doing so. While ideologically driven revealing is not common to all firms, it a strong motive for firms to engage in revealing.

Inducing industry advancements was categorised as an altruistic driver because the potential benefits extend beyond the revealing firm. In other words, these firms are driven by the need to collectively develop as an industry. The responses provided by the case firms indicate that over and above any benefits to the firm, they focus on developing areas of shortcoming in the industry.

For example, EVD's intention to create an environmental impact is closely tied to promoting improvements in the industry. They wish to accelerate the improvements by establishing operational best practices and filling any knowledge gaps in the industry. E.g. encouraging clients to give away building designs with complete instructions for replication.

SMX's intention in revealing is to encourage the industry to embrace best practices for streamlining operational aspects such as forensic evidence collection. By revealing the knowledge and experience gathered over time and providing training to the stakeholder parties, they aim to improve evidence collection mechanisms within the industry.

Goal driven revealing covers specific internal goals that firms expect to achieve, as well as specific firm requirements they aim to address through their revealing activities. The cases exhibit sourcing knowledge, capabilities or market access, image building, claiming ownership of knowledge and creating delayed revenue models as firm-centred requirements that drive revealing.

SMX, RQL, and TTR expressed that one motive is to gain knowledge, capabilities or market access through revealing. They stated that having to reveal some internal knowledge in exchange for inputs is inevitable in the process. The documentary evidence further supports these claims, including records of partnership arrangements that lay out the mutual benefits as firms clarify what knowledge is shared in exchange for the partners' inputs. As further explained by Ken in a corporate blog post, "Connectivity is important for accessing knowledge and expertise to innovate" at TTR. Firms can never have all the resources needed for internal

innovation available within the firm, and therefore need to source some of them externally (Chesbrough, 2003a). However, gaining market access as a driver is an additional finding.

Disclosing knowledge in exchange for exclusive rights is a strong driver for RQL and TTR. Revealing as a defensive mechanism is when knowledge is disclosed to publicly claim rights to it, but this does not include an intention of revenue generation. The IP policy documents of both firms classify publishing as a defensive mechanism. However, both firms clarified that by publishing they mean patents, because by this means they retain exclusive rights to the knowledge in exchange of public disclosure (Bloch, 2013; Cohen et al., 2002; Jaffe, 1986).

Delayed revenue creation is a new category that emerged from the case data. SMX, RQL and TTR explicitly stated that some revealing activities are motivated by their potential to generate revenue. For example, RQL's partnerships are mostly with suppliers who distribute their products (e.g. NTI), or clients with whom they are seeking to co-develop solutions (e.g. BT, AP). While suppliers distribute their products for potential sales, clients will purchase their customised solutions from the firms. In both instances, the free-knowledge from the firm is important, not only to secure the partnership but also to ensure that it leads to sales.

EVD and LMO displayed evidence of revealing leading to increased sales, however neither firm explicitly named potential revenue as a driver. This is understandable because their primary objective in revealing is to make an impact.

In addition to the other drivers, SMX expressed that 'first and foremost', they are legally mandated to reveal. This is an external pressure forcing the firm to reveal. However, this factor is specific to a type of organisation – generally government or publicly funded organisations. As this may not be a common driving factor found across commercial entities, it was eliminated from the analysis. Table 5-5 presents the drivers by firm to illustrate their distribution across the firms.

Table 5-5: Drivers of revealing by firms

First order	Second order	Firm/s
Openness as a core founding value of the firm	Ideological motivations	EVD, LMO
Revealing to create social/environmental impact		EVD, LMO
Establish operational best practices in the industry	Induce industry advancement	EVD, SMX
Revealing ongoing work to avoid repetitive R&D		EVD, SMX
Desire to fill technical knowledge gaps in the industry		EVD, SMX
To source knowledge or capabilities for internal innovation	For internal advancement	SMX, RQL, TTR
As an image building exercise – reputation and validation		SMX, RQL, TTR
As a defensive strategy to claim ownership of knowledge		RQL, TTR
Create delayed revenue models		SMX, RQL, TTR

The firms that displayed altruistically driven revealing seem to provide unrestricted access to revealed knowledge. The analysis to identify associations between the drivers and the revealing behaviours focused on finding the links between them. As illustrated in the case descriptions, firms used a rational process for identifying the specific mechanism/s for the intended revealing activity. Based on the interview data from SMX, factors associated with altruistically driven revealing provide a strong motivation to publish knowledge in academic and scientific publications. Such publications by design are unrestricted in terms of access, but selectivity can be applied to the amount of knowledge revealed depending on the respective knowledge base, for example a section of knowledge pertaining to a larger project, individual research outputs, or collaborative outputs. However, EVD and LMO were both explicit in clarifying that they do not deliberately restrict access to knowledge, or practice selectivity with regard to revealing. The latter observations can be explained by the firms' ideological drivers. One reason these firms offer unrestricted access to the knowledge they reveal is because their intended outcomes depend on a wide group accessing and reusing the knowledge. For example, Andy emphasised they put extra effort into revealing their knowledge through multiple sources because they want everyone to use it to 'make an impact' (2016). LMO uses multilingual presentations, workshops, and discussion platforms to deliver their knowledge to a larger user-base. SMX too uses multiple platforms, ranging through publications, conference presentations and hands-on training to ensure that the knowledge reaches as many users as possible, and in the intended context.

The firms that are goal driven to reveal seem to prefer restrictions either in access only, or both access and content depending on the requirements. Simply restricting access to revealed knowledge without selectivity in terms of content was rare among the firms. In SMX, this was indicated by interns and researchers being allowed spend time in the firm to learn and participate in research and development. The provision of such in-house training for specific groups is important to reputation and image building for the firm.

Formal partnerships seem to be another common practice used by the firms in relation to the goal driven category. These formal partnerships ensure that firms are sharing only the knowledge required to achieve the specific goal, and they do so only with the necessary users. For example, partnering to source knowledge inflows requires firms to identify potential 'partners' that possess the required knowledge and are willing to share it. Revealing that is goal driven does not call for an extremely open approach, which is compatible with the characteristics of R&D collaborations (Bogers, 2011; Pisano & Verganti, 2008).

Collaborations are formed to achieve specific internal goals that seem to determine the formulation of the partnership (see Pisano & Verganti, 2008). According to the findings, the case firms that are organically wary about disclosing internal IP seem to be driven by these factors in their revealing.

The only exception to this association between goal driven objectives and access/restrictive revealing behaviours is revealing as a defensive strategy. Using patents as a mechanism to disclose knowledge is a defensive strategy that reveals knowledge components pertaining to a technology, providing unrestricted access but retaining exclusive usage rights to commercial appropriation within the firm – as with IPR-based OI for example (Henkel et al., 2014). However, the knowledge is in the public domain and so open to anyone. The rationale advanced by the case firms for doing so is to claim the rights to a piece of knowledge they know is going to be 'difficult to keep as a trade secret' (RQL, 2017; TTR, 2017). Accordingly, such activity falls into the category – 'need for defensive publication'. But such defensive patenting by RQL and TTR is not relevant to the restrictive revealing behaviour that is most prominent in these firms. Therefore, revealing as a defensive strategy relates more closely to content-controlled revealing. However, as SMX was the only firm that exhibited content-controlled revealing, there is insufficient evidence for such an association. This is not surprising since SMX is predominantly a research-based firm, although with significant commercial intent. They are therefore not inclined to reveal as a defensive strategy, as this is linked to potential commercialisation of knowledge. This was evidenced by the request from Mike, the R&D Manager, to conduct a seminar for the SMX employees emphasising the value of commercialising knowledge, as in general scientists are wary of commercially exploiting research outputs. An informal conversation with an SMX employee further confirmed that most 'employees in SMX are scientists…so, they prefer to publish rather than protect through patents' (field notes, 2017).

A summary of the associations between drivers and revealing behaviours is presented in Table 5-6.

Table 5-6: Links between drivers and behaviours

Second order	Access	Content	Revealing behaviour/s
Ideological drivers	Unrestrictive	Unselective	Extreme revealing
Inducing industry advancements	Unrestrictive	Unselective; selective	Extreme revealing; content-controlled revealing
Inducing internal advancements	Restrictive	Unselective; selective	Access-controlled revealing; restrictive revealing

Based on the findings for second-order driver categories and their presence in the firms, connections between revealing behaviours and drivers can be visualised as in Figure 5-1.

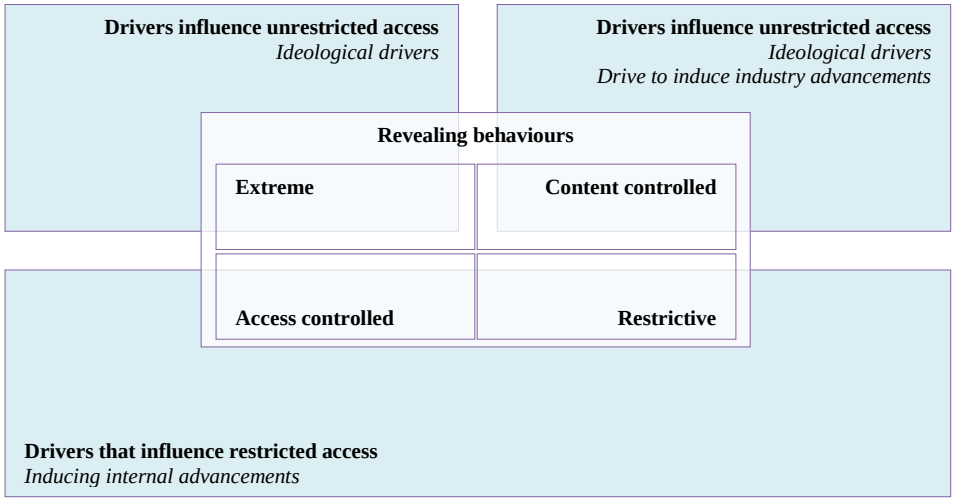

Figure 5-1: Links between drivers and revealing behaviour

In summary, the case data shows that regardless of the how much knowledge is revealed, firms with revealing profiles for unrestricted access are altruistically driven to reveal. The extreme revealing firms are strongly motivated by ideological drivers. On the other hand, firms with profiles for restrictive access, regardless of the content dimension, are goal driven.

5.3.2 Firm capabilities and revealing behaviours

These capabilities are the capacity of firms to combine organisational resources to achieve set goals (Amit & Schoemaker, 1993; Eisenhardt & Martin, 2000). The focus in this study was identifying the activities, routines and processes relevant to knowledge resources within revealing activities.

13 first-order categories were identified through the coding process and subsequently grouped into five capability groups: 1) Codification of knowledge, 2) Presentation of knowledge, 3) Making the knowledge selectable, 4) Managing risks of oversharing, and 5) Prudent management of the revealing process. Table 5-7 presents the cross-case data representative of the capabilities of the five firms.

Table 5-7: Firm capabilities and associated representative data

First order	Representative data
Capabilities to create content suitable for revealing	
Codification of knowledge	
Academic training to codify knowledge	"Having done research and having written a thesis, it gives you abilities [sic] … I learned a lot while doing my master's thesis… it's just like understanding basic things. Sometimes at Uni, they don't seem very important but just finding the right sources and looking for … yeah, just crediting people and looking for and understanding what a reliable source is, what isn't. I guess that's really it." (Cathy, personal communication, October 25, 2016) "So, we decided as we get attention, why don't we tell it better. *I have a background in communications*. I have been looking for projects around sustainability to create educational campaigns in." (Andy, personal communication, October 14, 2016) "We pretty much had the capabilities inside. For publications, we have scientists who have academic records working for us. We've got a very skilled workforce including research scientists, technical experts, engineers, etc." (Vince, personal communication, July 05, 2017) R&D manager has a PhD and promotes collaboration to develop better solutions – internal blog posts on collaboration. (TTR, field notes, 2017) "We are the largest employer of microbiologists in NZ. So we are very strong in that area and we have very strong track record and out scientists are well regarded in that area." (Tod, personal communication, August 30, 2017)
Simplifying complex knowledge	"There are the engineers and the architects; them being there is really important but then to the storytellers and writers it's important that we know a little bit about the subject but also important that we don't know too much because it has to be filtered through us to be spoken about to somebody that does not know anything. So the most important things is that we can communicate well to somebody that does not understand the subject." (Andy, personal communication, October 19, 2016) "I don't have the technical understanding an Engineer has or I never will. I am not interested in the nitty gritty of the technical things. But I have enough knowledge to sort of get the bigger picture. So I guess the capability is 'not knowing enough' or just knowing enough to understand what the big picture is and being able to write to explain that. And not knowing all the details because if I knew all the details, I probably will try to write down all the details and the complicated stuff." (Cathy, personal communication, October 25, 2016). Sprints on 'content review' comments on the simplicity in language, effective presentation, visualisation of ideas, etc. (LMO field notes, September 16, 2016)
Presentation of knowledge	
Ability to use a variety of communication platforms	"So, part of the campaign is to work out a long-term strategy – what are we going to tell them? When? The actual execution of it is we create articles, videos … For the [South Island project] we are creating on site education content – Signage. We created websites to hold all that content and data. When people stay down there they'd be able to read how the buildings performed and interact with the building as well." (Andy, personal communication, October 14, 2017) "So our website is on …. And videos on Vimeo. We use a bunch of devices and tools to get the data from the house to the website. We have a cloud to store data from different projects. These all based on open source servers." (Ben, personal communication, October 19, 2017) "I am in charge of the translation as well. So LMO [product related knowledge] is being translated to 33 different languages." (Fiona, personal communication, 2017) "We use our blog quite a bit. … also, we collaborate with journalists who sometimes write articles about us, and even twitter. I'd say those are the main ways that we are getting the word out. We are currently doing some research which you are probably aware of on the stories of our users. So, we are doing more video about that, sort of collecting a database of user stories that we can better understand and also share the impact of LMO so those practices we would also share. So, the video would be another medium." (Joanna, personal communication, 2017)

First order	Representative data
Capabilities to strategically management the revealing process	
Making the knowledge selectable	
Having internal IP management protocols	"I have an IP register … Right now, employees have to go through me to find out if a certain IP is disclosable or not." (Patric, personal communication, September 13, 2017) "Because of the nature of our business there is a lot of information classification going on in terms of what is confidential or secret or all kinds of stuff that exist here." (Nick, personal communication, August 09, 2017) "[One of my roles as the R&D manager is] IP management – basically handling the patenting process" (Ken, personal communication, August 11, 2017) "We threw an exercise of evaluating our IP, know-how, our trade secrets and categorising it. And then putting in place a process by which depending on the category, you could disclose or not. So you could disclose it under certain conditions. So, there were things that you would never disclose, they wouldn't ever be disclosed even with an NDA. There were things that could be disclosed with an NDA. And there were things that could be disclosed without an NDA to certain types of people, and then there were public [category] – things that could be displayed on our website, etc." (Vince, personal communication, July 05, 2017)
Ability to modularise knowledge	"We've defined our IP and we've split up into buckets. Like, this is something that we all share openly, and this is something we'll share with designated partners under an NDA, and then there is stuff that we don't share." (Zander, personal communication, August 14, 2017) "We protected our core know-how. At the time we realised we needed to have some rules around disclosure. We threw an exercise of evaluating our IP, know-how, our trade secrets and categorising it. And then putting in place a process by which depending on the category, you could disclose or not." (Vince, personal communication, July 05, 2017) "Our categories include all those different levels. E.g. if we characterised algorithms, we have identified which can be disclosed which can't." (Vince, personal communication, July 05, 2017) "… There was a competing product [with DIP] which was pretty much a black box. The analysts didn't know really how it worked, key algorithms were proprietary secrets, and they weren't released. When the DNA analysts go out to defend in the court, they really struggled with that. So we at SMX made the decision that rather than tie up our key algorithms in patents or not publishing them, we do the opposite. We didn't patent, we published all our algorithms in scientific journals. So that people could point to them and say these are the published algorithms, this is how DIP works, makes their life really easy!" (Patric, personal communication, September 13, 2017) "From just releasing that framing design and not explaining it to people, you are kind of giving the people the sense that they will be able to achieve this thing, where as they probably can't. They need the kind of expertise to guide them through it and keep asking that framing/building company all those questions that we had to ask." (Andy, personal communication, October 14, 2017) "We are open source. We give away not just our software, but we have a free version of our service available as well. It is part of our ethos to always enable or to always have a free version." (Greg, personal communication, September 16, 2016) "We also have a paid version of the software. That is the area that we were working on building value particularly for businesses and organisations to have a budget and are willing to pay for additional functionality or added value. [He explained what additional features are included in the paid packages, domain names, SLACK integration, etc.]" (Greg, personal communication, September 16, 2016)

First order	Representative data
Managing risks of over sharing	
Identifying risk-reward balance	"The key thing is, once you've done that categorisation [IP strategy], you can apply that to a given scenario and you can fine-tune it for that scenario. It is all about risk and reward and you really have to evaluate from a business sense – that is a business decision. We as a senior leadership team would look at it from a case by case basis." (Vince, personal communication, July 05, 2017) "We are part of the business development and commercial team. Our role in SMX is basically how SMX developed its business [sic] – business would be defined in that regards as research as well commercial revenue. Creating new opportunities, helping our scientists and research office to be successful, anything basically that is not business as usual that falls into growing our research, growing our reputation, or growing our financial revenue." (Tod, personal communication, August 30, 2017) "Different relationships demand different strategies. With firms; the first question we ask is, is this a competitor. If so, we will not be sharing much. But even a competitor can be different. They may be catering a different market. For example, we make black units, they make blue ones. We both have similar products but are operating in different markets. Not going head to head in competition. In such cases, we may have fruitful beneficial relationship. These relationships lasts years." (Ken, personal communication, August 11, 2017)
Identifying, evaluating and investing efforts to understand partners	"We avoid R&D wastage by involving design thinking in these collaborations." "We will research, look on internet, their revenue history. We use the same process we use to evaluate suppliers. For example, their age, annual revenue, size of the firm, technological capacity, etc. We basically need to know that we can have a lasting relationship." (Ken, personal communication, August 11, 2017) "Our preference is to spend more time getting to know the partner. [They use design thinking for this process]. May be looking for a small project initially and if that works well, scaling that up. That process helps to de-risk them." (Vince, personal communication, July 05, 2017)
Establish contracts and guidelines for revealing	"We were very careful in that sense. We had an NDA in place. We protected our core know-how. At the time we realized we needed to have some rules around disclosure. We threw an exercise of evaluating our IP, know-how, our trade secrets and categorizing it." (Vince, personal communication, July 05, 2017) "We have locked down the operating system so that you can't log in. the software and firmware within each module is all protected by encryption so that you can't read it off." (Will, personal communication, August 29, 2017) "There are IP agreements – legal – in place with the companies along with commercial agreements." (Ken, personal communication, August 11, 2017) "Once we realised what the potential of it might, we started taking measures around protecting the source code, which is the biggest thing we did. It used a standard encryption technology and access control to the code. We have a very specific set of discipline around making changes to the code. One of developers cannot just go in and change the code. We are looking at very specific high levels of data obscuring technologies and specific types of copyright protection relevant to certain specific countries. On one hand we are open but on other hand we are closed where it needs to be closed." (Patric, personal communication, September 13, 2017)
Prudent management of the revealing process	
Having a long-term action plan for the revealing *activities*	"There are overarching kind of strategy work as well, so like in our educational campaign we are thinking two years ahead, so that we are thinking really carefully about what the vision in two years, that we want kind of get to. So, we are not just writing out from today part of a two years story. And creating that big long-term strategy is, the strategic thinking around the media. We have awareness around particular subjects are of interest to the public when we get picked up by journalists. We release a story on rainwater capture at the end of the summer when everyone is freaking out about water shortages because we know the journalists would pick it up like that [snapping the fingers]. So, we are timing one of our projects to lead into the national elections at the end of next year. So that the information will get into will be leading up to that [snaps fingers]." (Andy, personal communication, October 19, 2016)

First order	Representative data
Adjusting revealing *techniques based on timely requirements*	"These days people are really picking up lot of knowledge sharing more informally. But also having more systematic workshopping and open forums for specific users. I believe increasingly people are using video. You know gaining a popularity especially from the millennial demographic in terms of picking up ideas about how to get things done." (Joanna, personal communication, March 14, 2016)
Contingently adjusting the disclosure rules for k. modules	"By having categorised it [IP in the firm] if there is a conflict – they need this bit of information we've said is trade secret – we look at the commercial over lay: do we need to disclose this to get good commercial benefit? If we say yes, because the commercial opportunity is really exciting, is there a way of disclosing it that will still protect us? If so, then we'd fine-tune it. E.g. if they want the source code, well they can have the source code, but we'd remove some detail in it and say you can't have it, or we'll provide that later or we'll provide that when you demonstrated you are really committed to this partnership." (Vince, personal communication, July 05, 2017) "There was a case recently where we needed to share some firmware relevant to the sensor head component. To share that with NTI. That would have been against the policy, so we actually changed the policy in that case." (Zander, personal communication, RQL, August 14, 2017)

Two themes emerged from the first- and second-order categories for capabilities – codification and presentation seem to be relevant to *creation of content in a format suitable for revealing*, and the remainder are relevant to the *management of the revealing process*.

Codification converts knowledge into transferable units. Codification of scientific knowledge requires human capital with appropriate academic training, e.g. PhDs, research scientists (Gruber et al., 2013; Simeth & Lhuillery, 2015). SMX, RQL and TTR indicated they have the necessary expertise within their firms to conduct research as well as publish the output in academic and scientific journals. In all three firms, the research process is overseen by PhD holders.

Having a co-founder (Andy) with expertise in mass communication has aided EVD in preparing knowledge for different platforms. They can simplify complex content into components that can be easily understood by a general audience. However, actively simplifying knowledge was only observed in EVD. The reason for this could be that the knowledge revealed by EVD needs to be understood by a diverse user base, ranging from the general public to professionals, in order to ensure diffusion and reuse. In contrast, the knowledge revealed by the other groups, and even in the public domain, will be utilised by a community with similar expertise.

Presentation of knowledge refers to the firm's capacity to use multiple platforms to share knowledge. This includes the ability to translate knowledge into multiple languages, use multi-channel dissemination, as well as being able to identify necessary channels suitable for different knowledge modules, the audience and their requirements. Both EVD and LMO

demonstrated capabilities in presentation. Furthermore, LMO is identifying and adopting novel presentation trends for effective dissemination of knowledge.

The other three groups/categories of capabilities – making knowledge selective, routines to protect against unintentional disclosure, and routines for prudent management of revealing – are relevant to managing the process of revealing at different stages. Capabilities that enable selectivity showcase the firm's ability to modularise knowledge and manage IP. The internal IP management protocols established by SMX, RQL, and TTR capture the IP management processes and IP policies implemented by these firms. These define the processes for identifying, protecting and sharing IP, and mainly consist of patents, copyrights, technology protocols and trade secrets. All three firms retain expertise within the firm to successfully manage this process.

Capability to modularise knowledge was demonstrated by all five firms. This is achieved through the IP management process. However, EVD and LMO, the extreme-revealing firms, are the exceptions. These firms do not use modularity for selectivity. Rather, it is used as a mechanism to manage the internal knowledge for effective positioning, i.e. identifying specific knowledge modules suitable for a specific audience. Specificity in audience does not equate to restrictiveness, but rather refers to the characteristics of a group (e.g. engineers, potential homeowners, not-for-profit groups, etc.). In LMO, modularity occurs naturally with the use of OSS principles for their core product, which separate the revenue model from the revealing process – e.g. source code from the software, user-assistance platforms from monetised services. In EVD, modularity is achieved at the planning stage of a revealing event when defining what knowledge components can be and should be shared – housing plans, water management systems. These stages of identifying knowledge modules, setting objectives, and identifying target groups are well documented, and are shared through the firm's website.

Additionally, RQL exhibited a unique expertise in defining disclosure boundaries for their internal knowledge modules. The firm's 'IP strategy' [different from the IP policy] explicitly demarcates knowledge modules that can be revealed under different circumstances. The initial exercise involved an external IP expert. However, the firm now possesses the necessary training and expertise to continue using the strategy, and to evolve through new additions to the list or by renegotiating the current 'buckets' when the need arises. This is a unique capability that other firms do not possess. This is explained in detail in the case description.

Capabilities for managing the risk of oversharing are evident in the restrictive firms. Identifying the 'risk-reward' balance in a partnership, understanding partner requirements, and establishing mitigation methods for oversharing are the inter-related processes used to manage risk. The risk-reward balance is evaluated at the partnership initiation stage. SMX, RQL and TTR, show expertise in conducting due-diligence, and evaluating the trustworthiness, and knowledge and commercial relevance of each partnership. All three firms have a dedicated commercial team handling the risk management process. Finally, all firms indicated the existence of internal processes such as formal agreements and creating knowledge 'black-boxes' to prevent unintentional leakages of knowledge.

Lastly, prudent management of the ongoing process was only evident in the most open firms, with the exception of contingent adjustments which were weakly supported across firms. However, the firms that showed prudence in management provided strong evidence for this capability.

EVD plans activities such as 'communication campaigns' spanning a lengthy period of time – two years for example. They envision the activities and milestones for each activity for intended time period and establish the activity plans at the beginning. The firm has established processes for gathering information and planning and deploying knowledge revealing activities in a consistent manner over the intended time period, across all projects. They even reveal the knowledge relevant to this planning process via workshops, and on their website and other media.

LMO indicated capability for keeping up to date with the changing trends in communication and knowledge dissemination methods. Using AI and bots for timely delivery of knowledge and modern platforms for knowledge sharing such as twitter and YouTube are among the adjustments LMO has made over the years in terms of delivery.

RQL demonstrated the ability to contingently adjust the disclosure rules of their IP strategy. The ability to foresee the need for a formal mechanism to assign disclosure rules as well as the ability to renegotiate 'IP buckets' are major capabilities used by RQL to customise the revealing activities contingently. The case description in Chapter 4 provides evidence of instances where prudent adjustments to disclosure rules have not only helped protect the interests of RQL, but secured profitable partnerships as well, as described in the example below:

> One of issues for that company to do the work, was they needed access to our source code for the firmware that we have developed in-house. We looked at our IP catalogue and the source codes of any products

> are trade secrets and should not be disclosed even with an NDA. But then we revaluated that source code and realised there are some source codes who had more core technology than others. Some codes were proprietary but did not contain any core knowledge or core-competencies. So, we realised we had to differentiate between different types of source codes. Once we revaluated those buckets, we realised that the source codes to the PM sensor weren't a trade secret and could be disclosed under an NDA. So, we revised that category. That enabled the project to go ahead. (Vince, personal communication, July 05, 2017)

One plausible explanation for not finding evidence relevant to prudent management in other firms could be that they did not explicitly declare such capabilities during the data gathering for this thesis study. These aspects of the revealing process may be so inherent to the firms that they can only be identified through an extensive observation exercise.

Table 5-8: Capabilities and the indicative firms

Second order	First order	Indicative case firm/s
Codification of knowledge	Academic training to codify knowledge	EVD, SMX, RQL, TTR
	Simplifying complex knowledge for a general audience	EVD, LMO
Presentation of knowledge	Ability to use a variety of communication platforms	EVD, LMO
Making the knowledge selectable	Having internal IP management protocols that define disclosable knowledge	SMX, RQL, TTR
	Ability to modularise knowledge	EVD, LMO, SMX, RQL, TTR
Managing risks of over sharing	Identifying risk-reward balance in revealing activities	SMX, RQL, TTR
	Identifying, evaluating and efforts to understand partners	RQL, TTR
	Establish contracts and guidelines for revealing through prior experience	SMX, RQL, TTR
Prudent management of the revealing process	*Having a long-term action plan for the* revealing *activities*	EVD
	Adjusting revealing *techniques based on timely requirements*	LMO
	Contingently adjusting the disclosure rules for knowledge modules	RQL

As shown in Table 5-8, codification of knowledge and capacity to make knowledge selectable seem to be common to all firms. Capabilities for making the knowledge selectable are useful for content-controlled revealing. Although, as pointed out earlier, the selectability applied to knowledge in extreme revealing firms is not to selectively restrict content, but rather to better position the knowledge modules when revealed. The ability to present knowledge via multiple platforms and in multiple formats ensures wider reach and seems to be consistent with the intentions of the extreme revealing firms.

Managing the risks of oversharing is important for the firms that are protective of their internal knowledge. Based on the findings, this activity is present in firms that control either or both dimensions of revealing. These firms displayed strict knowledge management protocols such as IP policies and guidelines. Accordingly, capacity to manage risks of oversharing can relate to all three of the more restrictive behaviours – content-control, access-control and

restrictiveness. Although capacities to prudently manage the revealing process provide interesting insights to the firms' revealing activities, they can be eliminated from the analysis on the grounds of inconclusive findings. These relationships are summarised in Table 5-9 below.

Table 5-9: Links between capabilities and behaviour

Profiles*	Second order	First order
All profiles	Codification of knowledge	Academic training to codify knowledge
ER		Simplifying complex knowledge for a general audience
ER	Presentation of knowledge	Ability to use a variety of communication platforms
CCR, RR	Making the knowledge selectable	Having internal IP management protocols that define disclosable knowledge
All profiles		Ability to modularise knowledge
ACR, RR	Managing risks of over sharing	Identifying risk-reward balance in revealing activities
RR		Identifying, evaluating and efforts to understand partners
ACR, RR		Establish contracts and guidelines for revealing through prior experience

* ER – Extreme revealing; ACR – Access controlled revealing; CCR – Content controlled revealing; RR – Restrictive revealing
# Only one firm in the profile category indicated these capabilities.

Figure 5-2 conceptualises the relationships between capabilities and the revealing behaviours based on the findings.

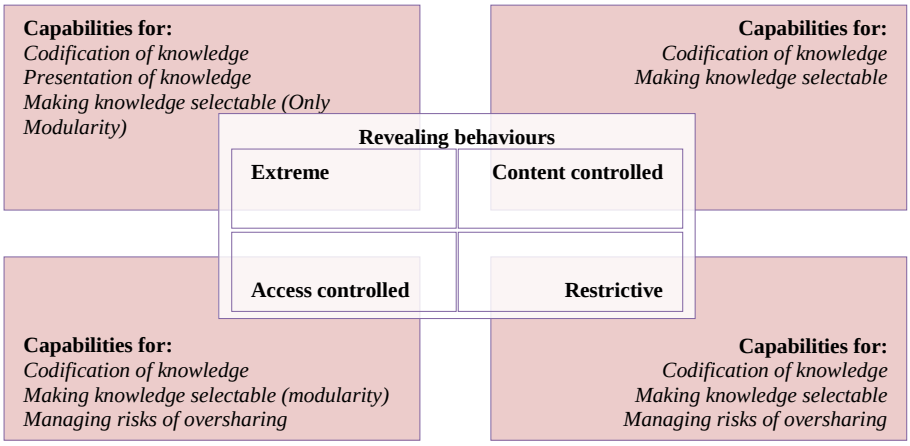

Figure 5-2: Links between capabilities and the revealing profiles

5.3.3 Strategic actions and the revealing behaviours

Strategic actions are specific activities identified from case data that seem to strategise the implementation of revealing. These actions assist the firm to achieve variety of strategic goals, such as increasing the openness, mitigating risks or simply managing the revealing activities.

The coding process identified eight first-order categories which were then grouped into four second-order groups: a) internal knowledge preparation, b) diligent partnership management,

c) enhancing reach, and d) enhancing reusability. Table 5-10 presents the cross-case data representative of the strategic actions.

Table 5-10: Representative data from the cases for the strategic actions

First Order	Representative data
Active selectivity and management for control	
Internal knowledge preparation	
Conducting internal reviews to avoid disclosing critical knowledge	"If we allow them to publish, we usually make sure that they do not mention the market (e.g. public safety, utilities, etc.)" "When we work with PhDs, master's students or Uni staff, we allow them to publish but we filter what is shared. (E.g. remove context of the technologies)." "We will see if it is critical to our products. If so, we won't allow it to be published. We usually won't put them in a position that they would come up with something that is critical to our products." (TTR, 2017) "We have a process in place where we protect any IP that needs protecting before publishing." (RQL, 2017) "They go through a process or end up embargoing the publications because they developed some unique science that may have a commercial value…we actually to get the correct protection in place before we can be more open about it." "We also make sure the critical company relevant knowledge is patented if they are being published." "There is a process that the employees need to go through for external publications – papers, conferences, posters. Once they've written their drafts, it is reviewed by, depending on who else is involved, one of our agents works with one or two independent peer reviews, so people who aren't part of the project but still from [the firm] - so internal peer review." (SMX, 2017)
Classification of knowledge for effective identification and management	"Our categories [IP buckets] include all those different levels. E.g. if we characterised algorithms, we have identified which can be disclosed which can't." "So, we know what we can and can't talk about." (RQL, 2017) "We have an IP policy in place which defines what to do when… Our IP policy is written to support our strategic direction. As a result, it describes a policy designed to execute on that strategic direction." (TTR, 2017) "Because of the nature of our business there is a lot of information classification going on in terms of what is confidential or secret or all kinds of stuff that exist here." (SMX, 2017)
Diligent collaboration management	
Use of formal and informal guidelines to conduct initial talks with partners	"There are MOUs, NDAs in place that would prevent critical knowledge being shared [to and by partners]." (SMX, 2017) "We would typically try to understand [in the initial talks]; what they trying to do; what have they tried so far; What their point of defaults; Why us? What do they gain from working with us? We kind of have a process where we do most initial calls even if we think it is going to be a waste of time just as a learning exercise." (RQL, 2017) "We've understood that in order for the relationship to last. We need to talk to three levels – the C level (CIOs, CEOs, CTOs); commercial level and the technical level all at once. if only at technical level, it is doomed to fail." (TTR, 2017) "We had a discussion last week with a company that we seek form a collaboration with. The call included technical, commercial teams as well as the CEO. We only had the technical team, but I am partially commercial too. And our CTO has given me power to develop the conversation. Our plan was to Find the people involved; If and how we wish to proceed; Package the NDA; Arrange a personal visit – to see if this company actually exist." (TTR, 2017) "There are personalities, politics, money, and many other aspects involved in a relationship. Therefore, it is important that we understand who we deal with." (TTR, 2017)

First Order	Representative data
Use of agreements and trust building during the collaboration	"Our preference is to spend more time getting to know the partner." (RQL, 2017) "There needs to be an element of trust and at the end of the day if you choose not to do anything, someone else does something with it then." (SMX, 2017) "We basically share on a need to know basis. Having said that we are happy to share whatever is required. Before we start sharing we would sign an NDA between parties. And we really trust our partners in that regard that they don't run away with it and do something naughty." (SMX, 2017) "There are IP agreements – legal – in place with the companies along with commercial agreements." (TTR, 2017) "NDA and commercial intent documents explain everything. Everyone knows who owns what." (TTR, 2017) "We try to understand what they are trying to achieve, how do they customise and tailor our products, etc. The more you understand the customer, the sticker the relationship. We become mutually dependable." (TTR, 2017)
Active dissemination for reuse	
Enhancing reach	
Positioning knowledge in the appropriate user domain	"One high level vision was to teach people of NZ about living buildings. They may not necessarily build similar buildings but will talk about them. A way to achieve this is by imagining one potential person and think about how the content can be delivered to this person." "But if we really want to make it open, we should be running a workshop with sustainable business network, and work with them to get the right people in the room who would be interested in it and go and do a presentation on it." (EVD, 2016) "Anyone can join the LMO community group. It says about where the product is going, we have open conversations with the members of groups, and say, 'we are going to do this functionality' and what does people think about it? So, we get feedback from our users, and we build the software with them. So, people are included in our decisions." (LMO, 2016)
Timing revealing activities with relevant external events for increased awareness	"We scheduled our relevant content to releases on the same months when the public cared about the Solar, or water shortages, cold and damp homes so that the information we put out is more likely to be picked up by the media and the public." "With the Ben's house, we timed our publications and media coverage. We released content… on the water systems. We timed the content to go into the water industry magazines two weeks before the media coverage to get the awareness." (EVD, 2016)
Enhancing reusability	
Peer validation of knowledge before revealing	"There was a little bit of a discussion around when do we make it open, because, it was not about protecting the IP but was about more if it is useful to anybody when it's got heaps of bugs and we don't have any documentation, and we don't even know if it's working, I should wait until the point it works and then make it available to the community that uses that cloud platform. We were pretty sure we decided that we will keep it private until we are done, and it is ready and then make it public." (EVD, 2016) "During sprints, members present work that they need suggestions or feedback on content relevant to the software or the two handbooks. The segment is called 'content review'. …The decisions about how to proceed with a publication or if something should be published were made on the spot involving everyone present. The presenter would ask 'what do you think about this?' and the members would present their ideas, suggestions, and their opinions on the matter." (LMO, Field notes, 2016) "There is a process that the employees need to go through for external publications – papers, conferences, posters. Once they've written their drafts, it is reviewed by, depending on who else is involved, one of our agents works with one or two independent peer reviews, so people who aren't part of the project but still from [the firm] - so internal peer review." (SMX, 2017)

First Order	Representative data
Presentation of knowledge for optimum reuse	"Well the architects in particular come and say 'well, you can share the plans, but we are worried that it would potentially exposes us to liability if they use them out of context and have bad outcomes." "[Client] said they are very good at simplifying things. They also keen on setting the context rather than the content. 'How can we create a context to allow whatever needs to happen and how can we help that to come out so it's nice and simple'- Andy explained that defining the Narrative [a stage of information gathering during the revealing event planning process] is related to the context that [Client] mentioned. How to make sense out of the content." (EVD, 2016) "I am in charge of the translation as well. So LMO [product related knowledge] is being translated to 33 different languages." "But what I think what bots do is, they integrate them in just in time so if they are muddling through and they are not getting let's say people to respond we can share 'oh, here some knowledge we have about ways to engage your group' for instance. We are also considering developing a just in time coaching network, so you know that would be another way to do knowledge sharing when people get stuck." "So, context is really important when you are working open. Making sure that if you are going to be working transparently that you are really work hard to make sure that the people who are consuming your information have the context they need." (LMO, 2016)

Two main themes emerge from the second-order categories – actions that enable the firms to be selective and prudent in revealing, and actions that enable active dissemination of the revealed content. The activities listed under 'internal knowledge preparation' and 'diligent partnership management' fall under the first theme, and those for enhancing reach and reusability fall under the second.

One of the major concerns for innovative firms when revealing is the risk of oversharing 'business-critical' knowledge (Foege et al., 2019; Hannigan et al., 2018; Henkel et al., 2014). Even though not at the same level of intensity, SMX, RQL and TTR all reported such concerns when participating in revealing activities.

A common mechanism used across these firms is to prepare the knowledge internally before revealing. This includes having an established system to segment the knowledge into modules and going through an internal review process.

Classification of knowledge modules is an activity in the modularising process. Modularising breaks down larger knowledge architecture into independent modules (Baldwin & Clark, 2000). Some firms indicated they attach a label to some knowledge modules to classify them into groups. These classifications are codified through IP policy documents, IP catalogues or registries, or other forms of knowledge management systems, such as document management systems for software development (TTR), or a standard protocol manual (SMX). The purpose of classification is to enable the reviewers to identify knowledge modules that can be shared

without affecting other 'modules' within the same architecture (Henkel & Baldwin, 2009; Sanchez & Mahoney, 1996). In the case firms, such classification of modules seems to be useful in two ways – 1) It enables selectivity if necessary; and 2) it helps to identify the critical knowledge modules (IP) the firm may choose to exploit internally.

The *internal review process* is used to filter the critical knowledge components to prevent them getting revealed. The review process is usually conducted by a dedicated team, e.g. the commercial team in SMX. Such reviews ensure that business critical knowledge and knowledge with potential commercial value are identified. When reviewing research outputs in particular, special attention is paid to identifying commercially sensitive knowledge. If the publications cannot proceed without the said knowledge components, the firms take measures to 'embargo' the publication until the knowledge is protected with IPR or commercialised or decontextualized before revealing. One method of decontextualizing is to remove the details of the application for a specific technology (e.g. public safety, utilities, etc – TTR):

TTR indicated that their research process is even more premeditated, especially when collaborating with universities. They intentionally control the research to not 'put them in a position that they would come up with something that is critical to [TTR] products' (Ken). This shows that the firms that practice selectivity in the knowledge revealed, purposively prepare the knowledge internally before it goes through for revealing.

Diligence in the collaboration initiation process, as well as during it, is seen in firms that are more restrictive in the revealing process. These collaborations are not always direct R&D engagements. However, as pointed out by the firms, 'partnering is essential' to access new knowledge, capabilities or commercial opportunities. When the collaborations are formed for a specific requirement, firms must ensure they select a partner that can satisfy that requirement.

SMX, RQL and TTR need to meticulously manage the process of partnership formation and maintenance as the objective is to identify and maintain suitable partners that can deliver their requirements. Accordingly, they seem to follow specific routines from the initial phase of 'getting to know' the parties. All three firms pointed out the necessity of establishing non-disclosure agreements (NDAs) from the beginning, even before formal discussions begin. RQL and TTR use an informal 'checklist' they have formulated over the years through experience that helps them understand the partners and evaluate the potential benefits. RQL pointed out that each initial meeting is unique and may take different formats. RQL modifying some 'IP buckets' to accommodate knowledge requests from partner-candidates before even formalising

the partnership is a unique example that showcases the lengths the firm goes to when forming suitable partnerships.

Engaging with multiple management levels during the initial conversations is one tactic indicated by TTR. One reason for this is that the success of the partnership depends on the corporate strategies of both firms. When the risk-reward balance in not equal on both sides, the collaboration fails. RQL provided an example one such failed collaboration.

> So, we ended up giving away our know-how, they didn't actually buy that number of products, and the project, internally-, it may have been about a 5-10 mil dollar project for them, which sounds like a very large amount but when you are a big corporate not so much and got cut internally. So, the project went nowhere! That is because their corporate strategy took them to go in a different direction. (Vince, personal communication, July 05, 2017)

SMX, RQL and TTR rely on contractual agreements such as NDAs and IP agreements to maintain partnerships free from the risks of knowledge misuse, conflict and ambiguity around IP. However, firms believe that formal methods alone cannot ensure a lasting and trusting partnership.

> I mean you can go and ask to sign an NDA but really?! You are not going to do that because it creates a barrier, a delay and doesn't build trust. Some orgs simply won't sign one. Some of them will but then what do you do subsequently when you think they took your idea and did something with it? (Mike, personal communication, August 09, 2017);

> … we are happy to share whatever is required. before we start sharing we would sign an NDA between parties. And we really trust our partners in that regard that they don't run away with it and do something naughty. (Steve, personal communication, August 30, 2017)

> Collaborative relationships are mainly based on trust. There are legal documents in place, but the level of trust is what is important. Because we provide unprecedented access to our technology and strategies. (Ken, personal communication, August 11, 2017)

> Our preference is to spend more time getting to know the partner. May be looking for a small project initially and if that works well, scaling that up. That process helps to de-risk them. (Vince, personal communication, July 05, 2017)

Both RQL and TTR reported that they spend time on understanding their partners. One method that both firms use is a 'design thinking' approach (Arnold, 1956) to understanding collaborators by personifying the partnering firm into a single critical person – usually the partner's liaison or project-lead. While they acknowledged the importance of trusting relationships, SMX does not demonstrate an explicit method of doing so. However, compared to RQL and TTR, SMX displays a more trusting demeanour in partnerships. One reason for this could be that as a requirement, they reveal knowledge intermediately during the collaboration process. This may mean that the knowledge is still in the development stages when revealed (Boudreau & Lakhani, 2015), and is yet to identify commercial applicability.

This can minimise the risk of losing value in failed or terminated partnerships. Furthermore, SMX's business model places more importance on sharing research output (commercialised or not) than development.

The last two second-order items – *enhancing reach* and *enhancing reusability* – are inconsistently supported when viewed collectively. Nevertheless, these actions are significant in the individual firms and strongly influence the effectiveness of their revealing activities. Actions to *enhance reach* are important for EVD and LMO – the firms that are not restrictive in the amount of knowledge being shared. Positioning knowledge in the target user domain ensures that the knowledge is received by an audience that may have an interest in it. The expectation is that this potentially will lead to a snowballing effect in the sector. Both EVD and LMO indicate the use of specific activities to increase reach. They both use multiple platforms, ranging from publications in print and online media, workshops, discussion forums and one-to-one consultations, not only to reveal but also to create awareness around the availability of revealed knowledge as well.

> We use our blog quite a bit. … we collaborate with journalists who sometimes write articles about us, and even twitter. I'd say those are the main ways that we are getting the word out. We are currently doing some research which you are probably aware of on the stories of our users. So, we are doing more videos about that, sort of collecting a database of user stories that we can better understand and also share the impact of LMO so those practices we would also share. So, the video would be another medium. (Joanna, personal communication, March 14, 2017)

As well as ensuring greater reach, use of multiple platforms enables the firms to deliver both tacit and explicit knowledge (see Nonaka & Takeuchi, 1995). In addition, LMO present the product related knowledge in multiple languages to ensure wider reach in the correct context.

> So LMO is being translated to 33 different languages. And it is mainly done by volunteers. I do the translation into Spanish and do support the Spanish users. (Fiona, personal communication, September 16, 2016)

EVD uses the approach of 'imagining one potential person and thinking about how the content can be delivered to this person' to understand the potential audience for the revealed knowledge and then tailor the complexity and relevance of the content (Andy, meeting notes, 2016). This seems similar to the 'design thinking' approach used by RQL and TTR.

Timing release of knowledge to align them with relevant world events generates considerably more awareness than revealing at unspecific times. A similar technique is used in product marketing to increase product awareness by promoting products during specific seasons (Radas & Shugan, 1998). EVD uses a timing strategy to release relevant content during specific seasons or around events – e.g. the run up to elections, political debates, droughts, social events,

and so on. Furthermore, they time the release of content within a project so that each content release complements the next one to reach maximum awareness. The strategy of timing is strongly embedded in EVD to the extent they schedule these revealing 'times' during the planning phase of 'communications campaigns' for a project. This was observed at a client meeting where Andy presented EVDs six-step process (presented in the case description).

Finally, methods to *enhance reusability* includes validation of knowledge and its presentation. Validation of knowledge is important to ensuring the revealed knowledge is final, accurate and 'bug-free'. This is different from the internal reviews discussed under capabilities. The focus here is to check for accuracy, general presentation and 'debugging' rather than identify commercially sensitive or potentially viable knowledge. EVD, LMO and SMX use an internal validation process to evaluate the 'readiness' of the knowledge. SMX has an established formal peer-review process that is a requirement for any knowledge that is identified for revealing. This is relevant to the revealing that uses open access mechanisms in the firms.

This is part of the *internal review process* that prepares the knowledge for revealing. LMO uses a similar approach via 'sprint meetings'.

> During sprints, members present work that they need suggestions or feedback on content relevant to the software or the two handbooks. The segment is called 'content review'. The decisions about how to proceed with a publication or if something should be published were made on the spot involving everyone present. The presenter would ask 'what do you think about this?' and the members would present their ideas, suggestions, and their opinions on the matter. (LMO, Field notes, 2016)

Such presentations ensure that the knowledge maintains appropriate context and is delivered effectively and efficiently for reuse. EVD and LMO are concerned about the accuracy of presentation. EVD's use of the systematic six-stage planning process dedicates one stage to simplifying and clarifying the context. This stage defines 'how to make sense' of the content and the 'timing' of release, during the planning phase for the revealing activity. By linking the two items, EVD aims to clarify the context for when to apply the knowledge revealed by the firm – e.g. to prevent damp housing during winter, or conserve energy power sources during periods of higher power bills. However, not all knowledge in EVD is linked to seasonal timing contexts. For example, house plans cannot be replicated without contextual information such as the geographical structure of the land, surrounding environment, sun orientation, etc.

> Especially in construction, it is not something that you just will be able to kind of pick up and drop them somewhere else. I guess they need to be designed for the site. And buildings we are working on are quite progressive and doing new things, that there is not a lot of people out there that know in the industry who knows how to use some of these methods. So, it is education at the same time. (Andy, personal communication, October 14, 2016)

To release such knowledge, EVD uses the workshops and face-to-face meetings where appropriate contextual information can be delivered.

LMO is concerned about the context but does not indicate any formal or informal process for addressing it. However, they translate the product related information as well as the 'handbook' into multiple languages to ensure a wider readership and potential reuse.

The 'collaboration clinics' provide the opportunity for users to consult LMO to clarify issues with reuse at no cost. A future addition discussed at the time of data gathering is to use 'bots' to identify when users are having trouble locating information and deliver knowledge and coaching 'just-in time' (LMO, 2017).

The strategic actions are presented by firm in Table 5-11.

Table 5-11: Strategic actions and indicative firms

Second order	First order	Indicative case firm/s
Internal knowledge preparation	Conducting internal reviews to avoid disclosing critical knowledge	SMX, RQL, TTR
	Classification of knowledge for effective identification and management	SMX, RQL, TTR
Diligent collaboration management	Use of formal and informal guidelines to conduct initial talks with partners	SMX, RQL, TTR
	Use of agreements and trust building during collaborations	SMX, RQL, TTR
Enhancing reach	Positioning knowledge in the appropriate user domain	EVD, LMO
	Timing revealing activities with relevant external events for higher awareness	EVD
Enhancing reusability	Peer validation of knowledge before revealing	EVD, LMO, SMX
	Presentation of knowledge for optimum reuse	EVD, LMO

Based on the case findings, the revealing profiles indicate links to the strategic actions as illustrated in Figure 5-3.

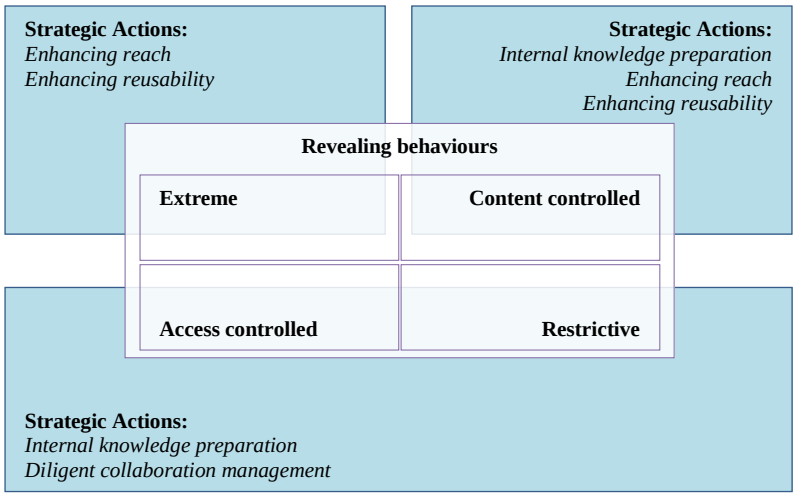

Figure 5-3: Links between revealing profiles and the strategic actions

The findings indicate that active selectivity and management are commonly used in firms that are selective in the knowledge they reveal and/or access. This is not surprising as the firms need to apply some strategic means of effectively separating the knowledge modules for selectivity and to identify the partners with knowledge of value for the firm. The preparation stage not only helps in terms of the selectivity of modules for open-access revealing, but also to identify the modules that are of value to the potential partners. Diligence in collaborations ensures that firms identify and partner with collaborators with potential for high value, but also helps maintain such partnerships in the long-run. As pointed out earlier, these firms consider a partnership as a long-term commitment rather than a one-time transaction. Therefore, strategies to build trust and avoid conflicts are essential for a lasting relationship.

Active dissemination seems to be crucial for firms that have open access (unrestricted) to knowledge. Tied to the drivers of revealing, these firms aim to achieve goals that necessitate wider awareness and reuse of the knowledge. The activities in this category ensure that the revealed knowledge is communicated effectively and is reused to achieve the targets anticipated by the revealing firm. SMX is an exception to this theorisation as it displays both active dissemination and active selectivity. However as discussed earlier, SMX displays both content-control and access-control behaviours equally prominently. It is therefore logical that the firm displays connections to both themes.

In summary, the preceding sections have analysed the case data to identify the links between the firm-level factors and revealing behaviours. The following section integrates these findings to answer the research question posed by this thesis.

5.4 Revealing in firms – Why and how firm implement revealing

This section integrates the analysis from the preceding sections to answer the research question – why and how firms implement revealing. Specifically, it discusses the influence of firm-level factors – drivers, capabilities and strategic actions – on revealing behaviours in firms and their implementation of revealing. The section concludes with the presentation of a refined conceptualisation for revealing that captures the variation in revealing implementation and the contributing firm level factors corresponding to implementation.

The analysis confirms that firm level factors are linked with their revealing behaviours. The revealing behaviours are characterised by access to the revealed knowledge (referred to as *Access* hereafter) and the amount of knowledge revealed (referred to as *Content* hereafter). Based on the analysis reported in the preceding sections, the associations between firm level

factors and revealing can be further developed as illustrated in Table 5-12. The table cross-references these factors with the specific variants of access and content. These associations provide insights to understand the relationships between the factors and the revealing behaviours. These are discussed in detail below.

Table 5-12: Links between the factors and the characterising dimensions of revealing

	Access		**Content**	
	Unrestricted	***Restricted***	***Unselective***	***Selective***
Mechanisms	Scientific publications; patents; open source contributions	Collaborations; workshops and training	Depends on the goals of the individual revealing activity	
Drivers	Ideological drivers; Industry advancements	Induce internal advancement	Depends on the goals of the individual revealing activity	
Capabilities	Codification of knowledge; Making knowledge selectable (Modularity only)	Codification of knowledge; Making knowledge selectable; Managing risks of oversharing	Codification of knowledge; *Presentation of knowledge*; Making knowledge selectable (Modularity only)	Codification of knowledge; Making knowledge selectable; Managing risks of oversharing
Strategic actions	Enhancing reach; Enhancing reuse	Diligent collaboration management	No specific actions identified	Internal knowledge preparation

The firms reveal to achieve specific goals that are reflected by the drivers. The drivers show connections with how the case firms enabled access to revealed knowledge. When the firm's goals are altruistic in nature, i.e. revealing for collective benefit rather than solely for the benefit of the firm, the access to knowledge is unrestricted.

When the goals are firm-centric, i.e. immediate benefits for the firm, firms opt for restrictive access. The analysis in Section 5.3.1 shows that a focus on differentiating access enabled the firms to achieve their goals effectively and efficiently. However, the connections between content and the drivers differed from one revealing activity to another, even within the same firm. Even though the case firms provided examples to elucidate why firms become selective in revealing content, they do not indicate clear connections that can be generalised. The revealing mechanisms mirror similar relationships with the access provided and the content of revealed knowledge. While the mechanisms show clear demarcations in access across all cases, differences in content are apparent based on the revealing activities.

Firm capabilities support their implementation of the chosen behaviours. Capabilities specific to each revealing behaviour assist with achieving the relevant combination of access and content specification. For example, content-controlled revealing is a mix of unrestrictive access

and selective content. Therefore, firm capabilities for codification, making knowledge selectable and managing oversharing facilitate the implementation of content-controlled revealing. An exception to this argument is found in extreme revealing, where the capabilities include ‘presentation of knowledge’. Capacity to present knowledge was found in the firms that reveal unselective content. However, this is not relevant to access-control behaviour that also shares unselective content. The key reason for this exception is that the firms demonstrating the capacity to present knowledge did so to make the knowledge available to a larger audience, which is a characteristic absent in access-controlled revealing. It is therefore unsurprising that this capability is only relevant to the extreme revealing firms.

Finally, strategic actions are useful in the management of revealing activities. The strategic actions useful for each behaviour relate to the access and content dimensions, as well as the drivers that influence the revealing behaviour. For example, firms with altruistic goals require the knowledge to reach a wider audience and be reused. Therefore, the drivers demand unrestrictive access and unselective content. The associated strategic actions ensure that the goals of revealing are met by implementing activities that further ensure the reach and reuse of revealed knowledge, such as timing, positioning, peer validation and presentation.

In summary, the findings show that the case firms implement revealing to achieve specific goals that are reflected by the drivers identified in the study. Further, the goals specify the appropriate combination of access and content that delineates the revealing behaviours, thus guiding the implementation process. The result of the implementation is revealing activities that may be a combination of suitable revealing mechanisms. The identified capabilities facilitate the implementation process by providing the necessary capacities required by the selected revealing behaviours and the revealing mechanisms. Finally, the strategic actions manage the revealing implementation. Except for extreme revealing, the activities making up the strategic actions involve a cautious approach, to some extent, to knowledge preparation and access management to ensure that the goals are met without risking the firm’s core knowledge. In extreme revealing, the focus is solely on deriving beneficial outcomes. Given that the extreme revealing firms in this study are ideologically driven to reveal, and not concerned about protecting knowledge, this association is not surprising. Based on the analysis and findings, Figure 5-4 presents the refined conceptualisation of revealing, capturing the revealing behaviours and their implementation. Based on this conceptualisation, the four revealing behaviours can be explained as below.

Extreme revealing is the most open form of revealing behaviour. Firms adopting this behaviour do not restrict access, nor are they purposively selective in the revealed content. Extreme revealing is motivated by ideological drivers. The case firms in this category showed strong motivation to achieve altruistic goals through revealing. They associated the achievement of the intended goals with the increased dissemination of an appropriate quality of knowledge for reuse (Allen, 1983; Harhoff et al., 2003; Pénin, 2007). The implementation of extreme revealing requires capabilities that enable firms to achieve the said goals and intentions. The study has shown that codifying and presenting knowledge and achieving modularity are the capabilities relevant to extreme revealing. The strategic actions ensure that the knowledge is disseminated to a wider audience and reused, which are both essential to achieving the goals.

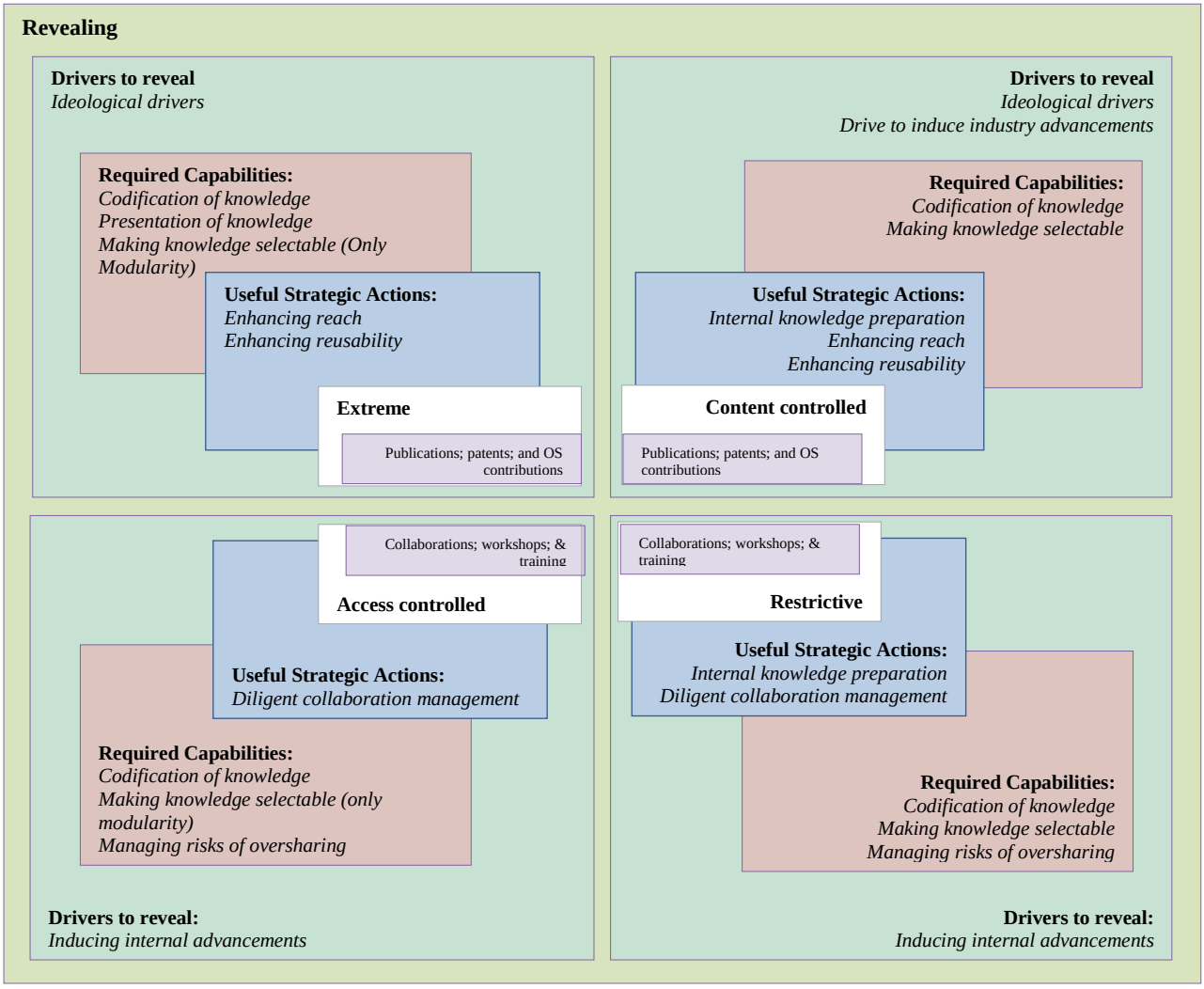

Figure 5-4: Refined conceptualisation for revealing

However, the findings for extreme revealing from this study comes with a caveat. Ideologically driven firms would be expected to reveal in any form by design thus making the findings for the specific type of firms appear tautological. Where extreme revealing is concerned, to be

tautological, all ideologically driven firms should be extreme revealers and all extremely revealers should be ideologically driven. OSS firms are ideologically driven to reveal (Raymond, 1999). However, not all OSS firms are extreme revealers (e.g. see Chan & Husted, 2010; Henkel, 2006; Henkel et al., 2014). Even though this provides a plausible argument to claim that the findings of this study on extreme revealing is not tautological, the issue still remains that ideologically driven firms would be revealing in any form and therefore, is not strategically implementing the process. Instead, revealing implementation may happen organically. Therefore, further exploration is required to validate the findings on ideologically driven firms and revealing.

Content-controlled revealing provides open access to selective content. Even with selective content, the firms that adopt content-controlled revealing aimed for collective benefits through the goals. However, selectivity in content helps to identify the knowledge that is most suitable for the purpose, especially when the goal is to induce industry advancements. Contrary to the current understanding (Henkel et al., 2014), selectivity in content in content-controlled revealing involves rational decisions that are both economic and altruistic in nature. Selectivity is important when the drivers to reveal call for identification of a target audience. Targeting does not necessarily mean restricting access (Pénin, 2007). For example, if the revealed content is presented at a conference, the firm is not actively restricting the audience, nor is their goal any less altruistic. However, the nature of the conference is a factor. For example, a conference on chemical engineering demands applying selectivity to the revealed knowledge to suit chemical engineers. Therefore, this behaviour is still content-controlled. Capabilities required for content-controlled behaviour are codification and capacity to make the knowledge selectable to ensure the appropriate knowledge can be selected for revealing. Strategic actions are focused on enhancing the outcomes through reuse and reach, as well as preparing the knowledge internally through a validation process to identify the knowledge modules required for revealing.

Access-controlled revealing is driven by the internal requirements of a firm. These requirements may include inbound knowledge flows, reputational gains, exclusive usage rights (contractual agreements) or delayed revenue. Access-controlled revealing restricts access to the knowledge while not exercising selectivity in the content. This behaviour requires capabilities for codifying and modularising knowledge, as well as capabilities to prevent oversharing. Strategic actions focus on the diligent management of collaborations, which are

generally the mechanism relevant to access-controlled revealing. The aim of these activities is to build trust and transparency in collaborative settings.

Finally, restrictive revealing restricts access as well as the content. Although similarly to access-controlled revealing, restrictive revealing is driven by goals to fulfil internal requirements, restrictive revealing is relatively more protective and closed, Capabilities for restrictive revealing focus on codification, selectivity of knowledge and protection from oversharing. Associated strategic actions facilitate preparation for knowledge selectivity through validation and classification, and diligence in managing partnerships through transparency and trust.

The four revealing behaviours provide insights to understand how revealing exists in firms. They further provide insights to understand why firms implement revealing in different ways and how such implementations take place.

5.5 Chapter Summary

This chapter presented the analysis and findings across cases. Table 5-13 presents the summary of findings resulting from analysis. Through discussion of revealing behaviours identified from the case firms, and analysis of the links between firm-level factors and these behaviours, the findings with respect to the research question can be summarised as follows:

- The analysis and findings show that firms implement revealing to achieve strategic goals identified by the firm. These goals set the objectives and define the appropriate revealing behaviours and corresponding mechanisms.
- Access to the revealed knowledge is the defining characteristic of revealing at the firm level. Even though the goals define the access as well as the content characteristics of the revealing behaviours, differences in revealed content are observable at the project- and activity-levels and vary even within the same firm.
- Codification and modularity are essential capabilities for all revealing behaviours. Although selectivity of content is not present in all behaviours, codification and modularity allow firms to identify core-knowledge and prevent leakage of the same if required. Furthermore, codification and modularity are used to enhance the outcomes of the revealing, even when the access and content are not restricted.

Chapter 6 discusses these findings and presents the theoretical and managerial implications. Furthermore, it discusses the limitations of this study that open up future research avenues.

Table 5-13: Summary of findings across the five firms

Firm	Revealing behaviour	Mechanisms	Drivers	Capabilities	Strategic Actions
EVD	Extreme revealing	Publications (incl. technical, practitioner, internet based) Training workshops and conference presentations; Open-source databases	Ideological drivers - Openness is a core founding value of the firm - Revealing to create social/environmental impact Induce industry advancement - Establish operational best practices in the industry - Revealing ongoing work to avoid repetitive R&D - Desire to fill technical knowledge gaps in the industry	Codification of knowledge - Academic training to codify knowledge - Simplifying complex knowledge for a general audience Presentation of knowledge - Ability to use a variety of communication platforms Making knowledge selectable - Ability to modularise knowledge Prudent management of revealing process *Having a long-term action plan for the* revealing *activities*	Enhancing reach - Positioning knowledge in the appropriate user domain - Timing revealing activities with relevant external events for higher awareness Enhancing reusability - Peer validation of knowledge before revealing - Presentation of knowledge for optimum reuse
LMO	Extreme revealing	Open source contribution Publications (internet based) Workshops & conferences (incl. online discussion forums)	Ideological drivers - Openness is a core founding value of the firm - Revealing to create social/environmental impact	Codification of knowledge - Simplifying complex knowledge for a general audience Presentation of knowledge - Ability to use a variety of communication platforms Making knowledge selectable - Ability to modularise knowledge Prudent management of revealing process *Adjusting* revealing *techniques based on timely requirements*	Enhancing reach - Positioning knowledge in the appropriate user domain Enhancing reusability - Peer validation of knowledge before revealing - Presentation of knowledge for optimum reuse
SMX	Content-controlled	Scientific publications and conferences Patents	Induce industry advancement - Establish operational best practices in the industry - Revealing ongoing work to avoid repetitive R&D - Desire to fill technical knowledge gaps in the industry	Codification of knowledge - Academic training to codify knowledge Making knowledge selectable - Having internal IP management protocol to define disclosable knowledge - Ability to modularise knowledge	Internal knowledge preparation - Conducting internal reviews to avoid disclosing critical knowledge - Classification of knowledge for effective identification and management Enhancing reusability - Peer validation of knowledge before revealing
	Access-controlled	Collaborations incl. visiting facilities,	For internal advancement	Managing risks of over sharing - Identifying risk-reward balance in revealing activities - Identifying, evaluating and efforts to understand partners	Internal knowledge preparation - Conducting internal reviews to avoid disclosing critical knowledge

Firm	Revealing behaviour	Mechanisms	Drivers	Capabilities	Strategic Actions
		exchange of personnel	- To source knowledge or capabilities for internal innovation - As an image building exercise – reputation and validation - Create delayed revenue models	- Establish contracts and guidelines for revealing through prior experience	- Classification of knowledge for effective identification and management Diligent collaboration management - Use of formal and informal guidelines to conduct initial talks with partners Use of agreements and trust building during collaborations
RQL	Restrictive behaviour	Restrictive partnerships; Scientific publications Patents Collaborations incl. visiting partner facilities, material exchange	For internal advancement - To source knowledge or capabilities for internal innovation - As an image building exercise – reputation and validation - As a defensive strategy to claim ownership of knowledge - Create delayed revenue models	Codification of knowledge - Academic training to codify knowledge Making knowledge selectable - Having internal IP management protocol to define disclosable knowledge - Ability to modularise knowledge Managing risks of over sharing - Identifying risk-reward balance in revealing activities - Identifying, evaluating and efforts to understand partners - Establish contracts and guidelines for revealing through prior experience Prudent management of revealing process - *Contingently adjusting the disclosure rules for knowledge modules*	Internal knowledge preparation - Conducting internal reviews to avoid disclosing critical knowledge - Classification of knowledge for effective identification and management Diligent collaboration management - Use of formal and informal guidelines to conduct initial talks with partners Use of agreements and trust building during collaborations
TTR	Restrictive behaviour	Collaborative development; Scientific publications Patents	For internal advancement - To source knowledge or capabilities for internal innovation - As an image building exercise – reputation and validation - As a defensive strategy to claim ownership of knowledge - Create delayed revenue models	Codification of knowledge - Academic training to codify knowledge Making knowledge selectable - Having internal IP management protocol to define disclosable knowledge - Ability to modularise knowledge Managing risks of over sharing - Identifying risk-reward balance in revealing activities - Identifying, evaluating and efforts to understand partners - Establish contracts and guidelines for revealing through prior experience	Internal knowledge preparation - Conducting internal reviews to avoid disclosing critical knowledge - Classification of knowledge for effective identification and management Diligent collaboration management - Use of formal and informal guidelines to conduct initial talks with partners Use of agreements and trust building during collaborations

CHAPTER 6 DISCUSSION AND CONCLUSION

This chapter presents a summary of the thesis, followed by a discussion of the findings and perspectives for future research avenues. First the chapter presents an overview of the study recapping the problem, research questions and aims. Second it presents the key theoretical contributions from the study for revealing, and consequently for Open Innovation (OI). The discussion that follows presents the implications of the key findings for the existing conceptualisation of revealing. Next, the chapter presents managerial implications with a focus on the implementation of revealing in firms without compromising their core-knowledge, and accordingly, 'best practices' that senior managers can use to implement revealing in a strategic manner. Finally, the chapter concludes with a discussion on limitations of the study that leads on to future research perspectives.

6.1 Overview of the study

This thesis explores the concept of *revealing* presented in OI. The purposive outflow of internal knowledge is an integral aspect of the OI paradigm (Chesbrough, 2003a; Dahlander & Gann, 2010; Gassmann & Enkel, 2004). As a purposive outflow of knowledge from the firm, revealing does not generate immediate revenue (Dahlander & Gann, 2010). While the benefits of revealing knowledge are well understood (e.g. Alexy, George, & Salter, 2013; Harhoff, Henkel, & von Hippel, 2003; Henkel, Schöberl, & Alexy, 2014), the need to understand how it is implemented in firms was identified, especially considering the challenges and risks attached to such knowledge outflows (Brunswicker & Chesbrough, 2018; Ritala et al., 2018). Therefore, this study set out to explore the variation in its implementation and the influence of firm-level factors on the implementation. The main research question posed was, *Why, and how do firms implement revealing?*

From the literature, a conceptual framework was developed to guide the empirical phase of the research reported in this thesis. The framework integrates four constructs relevant to revealing implementation - revealing behaviours, mechanisms of revealing, drivers to reveal and revealing capabilities. The four revealing behaviours were derived by systematically organising the different types of revealing available in the literature. The revealing behaviours – *extreme*, *content-controlled*, *access-controlled* and *restrictive revealing*, indicate that firms can vary the implementation of revealing by changing the amount of content revealed (hereinafter referred to as content), and the access provided to the revealed knowledge (hereinafter referred to as access).

The study applied a qualitative research design based on a multiple case study for two reasons. First, the absence of a coherent understanding to clarify the boundaries and integrate the different forms and types of revealing found in multiple theoretical fields was problematic in terms of operationalising revealing for hypothesis development (see Bacharach, 1989; Suddaby, 2010). Secondly, the research question called for a method of exploring the phenomenon in the participants' real world setting to identify new concepts and relationships, and clarify the prevailing conceptualisation of the construct (Edmondson & McManus, 2007). Multiple case studies allow the research phenomenon to be investigated in a 'real-life' context (Yin, 2018). Furthermore, the multiple case study approach allowed the case study protocols to be replicated across multiple firm contexts based on multiple sources of evidence (Baxter & Jack, 2008; Yin, 2018). Five firms from New Zealand were chosen as the case firms based on a pre-determined sampling criteria. Data from interviews, documentation and the field notes were qualitatively coded according to the framework constructs, and further categories emerged from the evidence during the process of coding. Rich case descriptions presented the background of the firms, and detailed descriptions of the revealing activities in the firms.

6.2 Summary of findings

One of the key contributions of the study is the framework it developed, which integrates and systematically organises different forms and types of revealing into four revealing behaviours. The case data was analysed to identify the respective revealing behaviours. This provided the basis for the mapping of mechanisms to the behaviours and subsequent analyses of the firm factors. Table 6-1 Summarises the association between the four behaviours and the relevant firm-level factors identified from the empirical study.

The findings show that firms reveal to achieve the goals represented by the 'drivers'. These goals characterise the revealing behaviours and identify the corresponding mechanisms. The firm's capabilities and their 'strategic actions' – a concept that emerged from the empirical study, facilitate the implementation of the revealing behaviours. Firm capabilities contribute to the implementation of the access and content characteristics of the revealing behaviours. Strategic actions, on the other hand, manage the implementation by contributing to enhance the outcomes or minimise the risks of revealing. The identified associations between the revealing behaviours and firm-level factors clarified the currently prevailing conceptualisation to illustrate implementation of revealing in firms.

Table 6-1: Revealing behaviours and the corresponding firm factors

Behaviours	Drivers	Capabilities	Strategic actions	Mechanisms
Extreme revealing	Ideological	Codification of knowledge Presentation of knowledge Making knowledge selectable (modularity only)	Enhancing reach Enhancing reuse	Publications (incl. technical, practitioner, internet based) Training workshops and conference presentations Open source contribution
Content-controlled revealing	Ideological Inducing industry advancements	Codification of knowledge Making the knowledge selectable	Internal knowledge preparation Enhancing reach Enhancing reuse	Scientific publications and conferences Patents
Access-controlled revealing	Inducing internal advancements	Codification of knowledge Making the knowledge selectable (modularity only) Managing the risks of oversharing	Internal knowledge preparation Diligent collaboration and management	Collaborations incl. visiting facilities, exchange of personnel
Restrictive revealing	Inducing internal advancements	Codification of knowledge Making the knowledge selectable Managing the risks of oversharing	Internal knowledge preparation Diligent collaboration and management	Collaborations incl. visiting partner facilities, material exchange

Additionally, the findings show that access to the revealed knowledge is the defining characteristic of revealing at the firm level. The strategic goals that drive revealing are explicitly related to the nature of access (restrictive/unrestrictive) represented by the revealing behaviour. Even though goals still characterise the content (non-selectivity/ selectivity) of revealing, differences in revealed content are observable at the project- and activity-levels, even within the same firm.

Furthermore, the findings indicate that codification and modularity are essential capabilities for all revealing behaviours. Although selectivity of content is not present in all behaviours, codification and modularity allow firms to identify core-knowledge and prevent leakage of the same if required. Furthermore, codification and modularity are used to enhance the outcomes of the revealing, even when access and content are not restricted. The theoretical relevance of these findings is discussed in the succeeding sections.

In summary, the findings from this study confirm the theoretical assumption that firms reveal in different ways depending on the firms' strategic requirements, as represented by the drivers. It further confirms that firm-level factors influence the implementation of revealing based on the specific revealing behaviours. The firm capabilities support the implementation of the behaviours through providing organisational processes and routines relevant to the corresponding mechanisms of revealing. The findings further show that capabilities to modularise and codify knowledge are relevant to any revealing firm, regardless of the behaviour. Finally, the strategic actions provide catalytic intervention in the revealing implementation process. These activities are complementary to the capabilities of the firm relevant to each revealing behaviour.

6.3 Theoretical contribution

This study makes three main contributions to the OI literature specifically to revealing, by a) introducing four revealing behaviours that clarify the current conceptualisation, b) presenting a conceptual framework that explains revealing implementation from a firm perspective by integrating revealing with existing theoretical perspectives and concepts, and c) presenting a coherent and overarching conceptualisation of revealing to facilitate its better operationalisation through scales that can be applied in multiple firm contexts in future empirical work. These primary contributions consequently contribute to OI by extending the understanding on revealing, the non-pecuniary outbound form of OI.

First, this study identified and presents four revealing behaviours in firms. These behaviours integrate currently fragmented insights on seemingly overlapping concepts in theory that represent free knowledge outflows from firms. Revealing is defined as a knowledge outflow from firms that does not generate immediate financial revenue (Dahlander & Gann, 2010). This inclusive definition permits a variety of concepts to be considered revealing. A review of the literature shows that the notion of sharing internal knowledge with outsiders has been around for decades. For instance, concepts such as collective invention (Allen, 1983), knowledge spillovers (Harhoff et al., 2003), knowledge disclosure (Boudreau & Lakhani, 2015; Pénin, 2005), and practices such as open and free software (Raymond, 1999), user innovation (von Hippel, 2005a) have always indicated free knowledge flows from firms to external parties. However, the revealing literature does not synthesise these ideas in the current scholarly conversation. In the absence of a precise conceptualisation, studies have used different definitions and terms to refer to revealing (cf. Huizingh, 2011). This has led to

conceptual ambiguity, inhibiting the potential to create an empirically derived coherent body of knowledge that is useful for theory development.

The study addressed this by reviewing the literature on seemingly overlapping concepts and arguing that *revealing* is an overarching 'umbrella' term that can be applied to any knowledge outflow across the firm boundary that does not generate immediate pecuniary incentives to the firm (Dahlander & Gann, 2010). Furthermore, this study presents a two-by-two framework that integrates the understandings across multiple theoretical fields to derive four revealing behaviours – extreme, content-controlled, access-controlled and restrictive revealing. This framework is an extension to the Dahlander and Gann OI framework, with a specific focus on expanding the non-pecuniary outbound form of OI. The four revealing behaviours represent the multiple ways that revealing exists in practice. The identification of such frameworks has influenced theory development in multiple fields, the Dahlander and Gann framework being a more relevant example.

Second, the study develops and uses a conceptual framework that extends the conceptualisation of revealing implementation in firms. The existing literature on revealing has a predominant focus on explaining the benefits of revealing, leaving the aspect of its application largely unexplored. The available empirical studies that explain the operational aspects are contextualised in OSS (Henkel et al., 2014; von Hippel & von Krogh, 2003). This study contributes to extend the conceptualisation of revealing by integrating insights on mechanisms and capabilities relevant to its implementation. The clarified conceptual framework presented in Figure 5.4 of the preceding chapter explains the variation in revealing implementation by identifying the links between the revealing behaviours, mechanisms, and firm-level factors such as the strategic drivers, revealing capabilities, and strategic actions. The study shows the choice of revealing behaviours depends on the drivers to reveal, and that revealing capabilities are complementary to the access and content characteristics of the revealing behaviour during implementation. The strategic actions indicated that firms use activities that provide catalytic intervention in the implementation process to optimise the outputs.

The study specifically identifies the *revealing capabilities* by integrating theoretical perspectives from resource-based view (RBV), specifically the dynamic capabilities (DC). The applicability of capabilities for revealing is understated in the existing conversation. Currently, this conversation is limited to OI, and outbound innovations in general (e.g. Cheng et al., 2016; Cooke, 2005; Grimaldi, Quinto, & Rippa, 2013; Lichtenthaler & Lichtenthaler, 2009). Integrating perspectives from RBV and DC addresses this gap by presenting theoretical

grounding to identify revealing capabilities. Furthermore, it creates a link between revealing and OI at large, with the mainstream theory that is currently a much-needed extension to both (Bogers et al., 2018; Vanhaverbeke & Cloodt, 2014).

Finally, the amended conceptualisation provides a starting point for empirical studies that examine revealing implementation. The conceptualisation is based on multiple firm contexts and presents insights that are applicable across a range of firms. This extends the prevailing, OSS-dominated understanding in a more generalisable context. Therefore, the conceptualisation presented in this study is replicable and testable in future empirical studies. The framework constructs identify specific items that enable operationalisations relevant to the implementation of specific revealing behaviour. Further, the findings provide a sound starting point for theory development that acknowledges nuances in revealing.

Consequently, the study contributes to OI by clarifying an inherent construct of the OI model (Dahlander & Gann, 2010; Gassmann & Enkel, 2004). The conceptualisation of revealing presented in the study links the concept with other OI constructs, such as outside-in and coupled processes. Ultimately, the study adds empirically obtained insights to fulfil the need for nuanced theory development in revealing, which is currently lacking (Bogers et al., 2018).

6.4 Discussion

This section compares and discusses the findings of the study against the existing literature. The discussion is organised under three main themes: (a) Implications of drivers to reveal on revealing; (b) Implications of codification and modularising capabilities for revealing; and (c) Implications of strategic actions for revealing implementation.

6.4.1 Implications of drivers to reveal on the revealing behaviours

The findings from this study show that firms reveal to achieve a set of goals that drive the revealing activities, namely ideological, to induce industry advancements, and to induce internal advancements. These goals define the combination of access and content that characterise the revealing behaviour. Ideologies and industry advancement are altruistic goals for firms to reveal. These goals lead to unrestrictive access with selective or unselective content. Inducing internal advancements is firm-centric and leads to restrictive access, with selective or unselective content. These findings have the following implications with respect to the revealing literature.

First, the findings on the associations between altruistic drivers and revealing challenge the arguments presented in the ‘selective revealing’ literature. Selective-revealing, whereby the

content is purposively selected, explicitly claims that the motivations for being selective are not altruistic (Henkel et al., 2014). In fact, this is presented as the key defining characteristic of selective-revealing compared to free-revealing. In the literature to date, free-revealing, where the knowledge is openly revealed without any selectivity, is associated with altruistic goals (Harhoff et al., 2003; von Hippel, 2005a). Access, on the other hand, shows prominence in the relationship as the altruistic or firm-centric nature of the goal is directly relevant to delineating any restrictions, or lack thereof. The open/closed disclosure literature (Muller & Pénin, 2006; Pénin, 2007), which grounds the access dimension, does not present explicit arguments to link the nature of the goals with access. However, the free-revealing literature implies that altruistically driven revealing leads to unrestricted access by making the knowledge a public good (Feller, 2005; Harhoff et al., 2003; von Hippel, 2005a).

On the other hand, these findings align with the arguments in the open source software (OSS) context. In OSS, the contributors share collectively held norms, beliefs and values advocating open and free knowledge sharing (Rolandsson et al., 2011; Stewart & Gosain, 2006; Ven & Verelst, 2008), which essentially links ideologies supporting revealing with unrestrictive and unselective revealing, i.e. extreme revealing. Nevertheless, OSS is used as the context to explain selective-revealing methods, by which means firms carefully select the content to reveal based on strategic rather than altruistic motives (Henkel, 2006; Henkel et al., 2014; Roberts et al., 2006; West, 2003). These are two opposing viewpoints concerning the relationship between motives and the characteristics of revealing activities are presented within the same context.

The findings from this study clarify viewpoints presented in the revealing literature regarding the effect of altruistic drivers on revealing behaviours. The findings show that selectivity of content is dependent on the specific goal that drives revealing rather than the general altruistic nature of the goals. Even with altruistic goals, the amount of content to be revealed needs to be well thought-out, depending on the specific altruistic goal – e.g., changing the behavioural norms of an industry (Stewart & Gosain, 2006; Zwass, 2010). This indicates that delineating the content for revealing needs to be a project-level decision, even though the access can be defined at the firm level.

Second, the firm-centric drivers pose strategic objectives for firms to restrict access. Findings on the associations between firm-centric drivers and the revealing behaviours align with the scholarly work on outbound OI and collaborative innovation (Bogers, 2011; Grossman & Shapiro, 1986; Kutvonen, 2011; Lichtenthaler, 2008). Revealing behaviours driven by firm-

centric goals seek internal development such as reputation and image building, inbound knowledge flows relevant to expertise and capabilities, or even potential markets, which are strategic requirements for firms' innovation activities (Cassiman & Valentini, 2016; Chesbrough, 2003a; Mazzola et al., 2012). The literature on outbound OI focuses on external exploitation of internal knowledge, explicitly stating these drivers as strategic objectives for firms (Kutvonen, 2011; Lichtenthaler, 2008). Kutvonen (2011) and Lichtenthaler (2008) focus on all forms of external exploitation, which includes strategic alliances and partnerships. Therefore, their claims apply to a broader outbound OI context that include both selling and revealing (for definition see - Kutvonen, 2011; Lichtenthaler, 2005). The existing revealing literature does not acknowledge the implications of revealing activities with restrictive access, as the focus is on revealing activities that are creating public good – e.g., free-revealing, selective-revealing, open disclosure. Therefore, these findings add to the existing understanding on revealing by emphasising the importance of revealing activities that are restrictive, yet beneficial to the firms.

The effects of firm-centric drivers on revealing are especially important to understanding the associations between inbound and outbound innovations in OI (Cassiman & Valentini, 2016; Gassmann & Enkel, 2004; Mazzola et al., 2012). The internal requirements reflected by the drivers are essentially inbound knowledge flows that result from the revealing activities. In the current literature, associations are made with collaborative innovation (Bogers, 2011). However, even in collaborative innovation, the knowledge outflow is not acknowledged as revealing.

In summary, drivers to reveal pose two implications for the revealing activities of a firm. First, contrary to the current understanding, the general nature of the drivers – altruistic or firm-centric – prominently define the access to knowledge. The variations in content are dependent on the specific drivers relevant to the revealing activity rather than the generic nature of the goals. This is important because it emphasises the need to define the level of content in revealing activities at the project or activity level rather than the firm level, regardless of the access. Second, the findings on firm-centric drivers link the revealing with inbound OI, thereby expanding understanding of coupled-process of OI. This further acknowledges the relevance of access restrictive revealing activities to the conceptualisation of revealing in OI.

6.4.2 Implications of codification and modularity for revealing

The study identifies codification and modularity as capabilities necessary for revealing. This adds to the revealing literature by explaining the implications of capabilities for revealing implementation.

First, the capacity to delineate the content via organisational processes such as *codification* is found in all revealing profiles. In the current literature, codification of knowledge is discussed with relevance to open science where firms require specific expertise to codify knowledge in the form of scientific publication (e.g. Gittelman & Kogut, 2003; Kinney, Krebbers, & Vollmer, 2004; Simeth & Lhuillery, 2015). However, the case findings extend the applicability of codification to other mechanisms. In the findings, codification includes the ability decontextualise and simplify (Cheng et al., 2016; Schulz, 2001), and the academic training to do so (Simeth & Lhuillery, 2015). Academic training for formal codification includes not just scientific publications and patents, but the training to codify to suit other platforms such as blogs, whitepapers, news articles and workshops material. It also extends to the codification of knowledge that is restrictive to selected groups, such as operational procedures and manuals, technological standards and protocols, and technical designs. Codifying internal knowledge enables the firms to identify the knowledge that needs to be protected and the components that can be revealed, e.g. RQL's IP strategy. Furthermore, codification helps the knowledge to be communicated appropriately via suitable platforms.

Capability to create content is part of a firm's ability to reconfigure and transfer knowledge resources (Eisenhardt & Martin, 2000). Also known as the desorptive capacity of a firm, it describes the firm's ability to identify and transfer knowledge to be exploited externally, especially in an open innovation context (Lichtenthaler & Lichtenthaler, 2009). The applicability of these capabilities across all four revealing behaviours is not surprising. Codifying knowledge makes it explicit and transmittable (J.-N. Lee, 2001; Nonaka & Takeuchi, 1995), and therefore more convenient to communicate and reveal. Desorptive capacity is required in firms to convert internal knowledge into transferable units (e.g. Hu, McNamara, & McLoughlin, 2015; Lichtenthaler & Lichtenthaler, 2009). These capabilities are relevant to revealing in general, regardless of the selectivity in content, or the access allowed to revealed knowledge.

Second, there are capabilities to make the knowledge selectable. In particular, the ability to *modularise* knowledge is relevant in all revealing behaviours. The ability to breakdown internal knowledge into manageable modules is evident in the IP strategies, policy documents and pre-

event (revealing events) planning activities (Baldwin & Clark, 2000; Baldwin & Henkel, 2012). Modularising knowledge is argued as an essential capability for sharing knowledge resources (Eisenhardt & Martin, 2000; Lichtenthaler & Lichtenthaler, 2009). However, with relevance to revealing, modularity is predominantly contextualised to the open source software (OSS) setting (Baldwin & von Hippel, 2011; Henkel, Baldwin, et al., 2013; Henkel & Baldwin, 2009). Scholarly work that integrates OSS perspectives on modularity suggests that it is useful for protecting firms from unwanted knowledge outflows as well as providing benefit by revealing the knowledge of value (Henkel et al., 2014; Lauritzen & Karafyllia, 2019). However, this study shows that modularity presents far greater implications for revealing, over and above making the knowledge selectable.

Modularising arranges the knowledge into smaller, independent modules that not only segregate, but also organise the content meaningfully. These modules work collectively in allowing the larger knowledge 'system' to function and be valued (Henkel & Baldwin, 2009). Breaking down the knowledge into modules allows firms to apply multiple disclosure strategies or intellectual property rights. For example, when selectivity of content is not of concern, modularity allows the firms to position the knowledge modules in respective target groups, for example by presenting knowledge relevant to structural engineers at a conference (evidenced in EVD). Furthermore, modularity is complementary to codification. By defining the boundaries of modules, complex knowledge is simplified (Henkel & Baldwin, 2009), thereby allowing the knowledge to be effectively codified. Therefore, even when the revealing activity does not demand selectivity, modularity is still important for decontextualising and simplifying knowledge into manageable, identifiable modules.

On the other hand, modularity also provides the convenience when collaborating in terms of sharing internal knowledge, as well for integrating the inbound knowledge flows into the firm's knowledge base (Baldwin & Clark, 2000; Sanchez & Mahoney, 1996). Modularising knowledge essentially disconnects the modules, to some extent, from the larger system. Therefore, disintegration, re-integration, or sharing modules does not affect the knowledge base of the firm (Baldwin & Clark, 2000; Baldwin & Henkel, 2012; Henkel & Baldwin, 2009). By using modularity in collaborative contexts, not only can firms reveal the knowledge without compromising the core-knowledge of the firm, they can also easily identify and re-integrate the knowledge received from the collaborators into their internal knowledge base.

In summary, capacities to codify and modularise knowledge are relevant to any form of revealing in firms. Both capabilities enable the firm to meaningfully arrange, sufficiently

simplify and draw boundaries around the knowledge for sharing externally (Baldwin & Henkel, 2012; Eisenhardt & Martin, 2000; Lichtenthaler & Lichtenthaler, 2009; Simeth & Lhuillery, 2015). Conversation on capabilities relevant to managing knowledge resources for revealing is non-existent. The scarce but prevalent discussion on capabilities in the OI context is presented within a generic, outbound OI perspective (Bogers et al., 2017; Lauritzen & Karafyllia, 2019; Lichtenthaler & Lichtenthaler, 2009). Therefore, establishing codification and modularity as capabilities essential for revealing introduces the capabilities discussion to revealing, to further understand implementation of revealing in firms.

6.4.3 Implications of strategic actions for implementing revealing

The strategic actions identified in this study manage the revealing implementation. Establishing the implications of strategic actions for revealing implementation introduces insights from several theoretical perspectives, such as knowledge transfer and strategic management of knowledge resources, to the revealing literature. Table 6-2 illustrates the theoretical perspectives that support the strategic actions identified in this study, followed by a discussion comparing the findings to the existing literature.

Table 6-2: Strategic actions in revealing implementation

Strategic action	Activities	Revealing behaviours	Similar theoretical perspectives
Internal knowledge preparation	Conducting internal reviews to avoid disclosing critical knowledge	Content-controlled, access-controlled revealing	*Internal testing and validation* (Hicks, 1995; Pénin, 2005)
	Classification of knowledge for effective identification and management		
Diligent collaboration management	Use of formal and informal guidelines to conduct initial talks with partners	Access-controlled, restrictive revealing	*Use of contracts and building trust in strategic alliances* (Jiang et al., 2013, 2016; Norman, 2002; Parkhe, 1993)
	Use of agreements and trust building during collaborations		
Enhancing reach	Positioning knowledge in the appropriate user domain	Extreme revealing, content-controlled	*Timing in innovation* (Pacheco-de-Almeida & Zemsky, 2012)*; Seasonal product introduction* (Radas & Shugan, 1998)
	Timing revealing activities with relevant external events for higher awareness		
Enhancing reusability	Peer validation of knowledge before revealing	Extreme revealing, content-controlled	*Internal peer reviews and testing* (Hicks, 1995; Lakhani & von Hippel, 2003; Pénin, 2005)
	Presentation of knowledge for optimum reuse		*Knowledge reuse* (Majchrzak et al., 2004; Watson & Hewett, 2006)

Preparing internal knowledge through review processes is essential to prevent valuable business-critical knowledge from leaking out. This process further involves activities that classify knowledge using IP policies or IP strategy documents to identify the purpose for each knowledge module and classify the conditions under which it is to be revealed. In the current literature, similar practices are only found in open science contexts where firms identify business critical knowledge that should be patented or kept secret before publications go live (Hicks, 1995; Pénin, 2005). Open science practices such as scientific publishing demand unrestrictive access. The study counters this notion by indicating that internal knowledge preparation is applicable not only to knowledge that is publicly disclosed, but even in instances where the knowledge is revealed to a selected few recipients, i.e. with restrictive access. Such activities during knowledge preparation ensure that the core-knowledge of firms is protected, new knowledge with commercial potential is identified, and only the knowledge relevant to achieving the strategic goals revealed.

Diligence in collaboration management ensures that partnerships are initiated based on the right information and maintained with trust. The activities include trust building through extensive exercises to understand the partners, investing time to discuss the expected requirements and mutual benefits, and maintaining transparency through contractual agreements that specify ownership and protocols for the post-collaboration outcomes. Such activities are discussed in strategic alliances studies (Jiang et al., 2013, 2016; Kanter, 1994; Norman, 2002), where the trustworthiness of potential partners is imperative to the continuance of a collaboration. Such activities help to establish lasting partnership. Long-term partnerships are associated with less risk for knowledge sharing due to the trust factor and familiarity with other partners' operational style (Cousins, 2002; Jiang et al., 2013). The activities identified under diligent management of collaborations align with these theoretical perspectives.

Enhancing reach ensures that the revealed knowledge is accessed by a wider group. Activities that ensure wider reach involve timing the revealing activities based on seasonal events, and/or positioning the revealed knowledge in suitable user-domains, e.g. delivering knowledge to groups or individuals who are searching for it. Innovation management presents the 'timing of innovations' where the introduction of innovations are timed, usually to be first-to-market (Pacheco-de-Almeida & Zemsky, 2012). In revealing, the research shows that being first-to-reveal is beneficial to increasing the chances of wide reuse (von Hippel, 2005a; von Hippel & von Krogh, 2006). However, counter to these concepts, timing and positioning as strategic actions for revealing are conceptually different from first-to-reveal. AS such, the strategic

actions are not specifically tied with the temporal factor of being the 'first', but rather the idea of revealing at the most appropriate time – a concept similar to the seasonal product placement found in marketing studies where product introductions are timed and positioned based on seasonal events (Radas & Shugan, 1998).

Finally, enhancing reusability through peer-validation and comprehensive presentation is found in extreme and content controlled revealing. Peer-validation ensures that the revealed knowledge is comprehensive, maintains sufficient context, and is accurate (Hicks, 1995; Lakhani & von Hippel, 2003). Presentation ensures that all necessary information for the reuse of the knowledge is comprehensibly presented for a wider group to understand. In the absence of a revenue stream, revealing is deemed beneficial only if the revealed knowledge is reused, especially in behaviours with unrestrictive access.

In knowledge transfer studies, scholars advance arguments for similar activities (Majchrzak et al., 2004; Watson & Hewett, 2006). However, these knowledge transfer studies adopt the perspective of the firm reusing the transferred knowledge. In contrast, in revealing, the reuse in strategic actions refers to the reuse of knowledge by recipients, not the revealing firm. However, knowledge reuse strategies confirm that firms actively engage in implementing actions for enhanced reuse, even though its application in revealing fundamentally follows the revealer's perspective rather than the re-user's.

In summary, strategic actions presents two implications for revealing. First are the activities to minimise the risks of oversharing and leakage of business-critical knowledge. Second are the activities to amplify the outcomes of revealing through enhanced reach and reuse where applicable. These activities integrate concepts from multiple scholarly fields to present insights for revealing implementation. However, this study does not claim this as an exhaustive list of activities. Rather, these activities present a starting point to explore the applicability of strategic actions in managing knowledge resources, to overcome the omnipresent challenges of revealing.

6.5 Managerial implications

The managerial implications of this thesis are primarily aimed at senior managers, such as those heading up research and development and other innovation related aspects in firms. These managers can use the associations found between key organisational constructs for revealing to implement revealing in firms. In particular, managers can identify 'best practices' for

revealing from the study, depending on the firm's strategic goals, and do so without compromising or risking the loss of the firm's core knowledge.

This study has demonstrated the basic variation in revealing implementation through the four revealing behaviours identified. It further clarifies when each behaviour is suitable by explaining the associations between the drivers and the behaviours. Understanding that revealing has numerous ways of being implemented helps managers to find the most suitable form for their firms, depending on their requirements. Furthermore, managers can use the conceptual framework to identify the necessary firm capabilities relevant to the behaviour/s. This is useful to understanding the existing lags in the firm in terms of capabilities relevant to managing knowledge resources that are necessary for revealing. For instance, the capacity to modularise knowledge is universally applicable regardless of the firm or the revealing behaviour. The case firms in the empirical study provided examples of how to modularise, e.g. IP policies and classification systems. Senior managers can use these examples to develop new capabilities in the firm, or 'fine tune' the existing capabilities to initiate and manage the revealing activities. The strategic actions provide guidance for managers on optimising the revealing activities. The examples in the study shows strategic actions relevant to each behaviour that can enhance the outcomes and manage the revealing activities.

Finally, the overall conceptualisation of revealing provides guidance to managers on implementing revealing, with a particular focus on strategic implementation. A key concern in organisations identified through the literature (Brunswicker & Chesbrough, 2018; Chesbrough & Brunswicker, 2014; Ritala et al., 2018), as well as through interactions with practitioners, is the loss of core knowledge. One of the main focuses of this study was to address this by developing a conceptualisation that could guide the implementation and management of revealing activities appropriately, yet effectively. The empirical evidence shows that revealing implementation is a top-down process in any firm, where the senior managers or, in case of small firms, the founders set the guidelines for the activities. Therefore, the findings of this study are relevant to senior managers of firms that wish to benefit from revealing.

6.6 Limitations and Future research

The main limitation of this study is the empirical context and lack of access to the participants. Both of these limitations provide avenues for future research. The lack of access to firms limited the empirical context in which to the study revealing behaviours. For instance, the findings for access-controlled and content-controlled revealing were both identified through

one case firm; The findings relevant to ideologically driven firms and its relationship with revealing appears tautological as discussed in findings. This raise concerns as to the validity of the findings across other firms. Furthermore, the current findings are contextualised to New Zealand firms. These firms share economic and cultural aspects that may differ from other geographical regions (Kimberly & Evanisko, 1981). Further exploration of the phenomenon in multiple geographical, firm and industry contexts, with substantial samples is required to address these concerns. This would further clarify the framework constructs and relationships.

A second limitation is in the scope of the study. A comprehensive literature review guided the development of a conceptual framework. However, selection of the concepts meant some had to be discarded (Huff, 2009). For example, this study does not consider the outcomes of revealing. Future research could benefit by adding this to the conceptual framework to evaluate the effectiveness of the selected revealing behaviour/s and especially its impact on the revealing firm. The model could be further substantiated by adding challenges and barriers for revealing implementation (cf. Mortara et al. 2010). An investigation of the same could provide insights to their influence on the implementation of revealing.

Finally, the study adopts a firm-level perspective. Guided by the existing studies and theoretical perspectives, it assumes that revealing is a firm level construct with homogenous units (Klein et al., 1994). Furthermore, this study only involved participants from the management levels directly involved in revealing activities. While this was an intentional choice, the study nevertheless did not involve operational level employees in the data collection. Firms are essentially multi-level organisations and the knowledge in firms exists at the individual level, i.e. the workforce. Moreover, the knowledge sharing relevant to the revealing activities occurs at the individual level. Therefore, further empirical studies need to be designed to account for the multi-level aspects of revealing (Bogers et al., 2017; Gupta et al., 2007). Such studies would add theoretical finesse to revealing, especially in understanding the challenges and the operational limitations in organisations. However, because the aim was to develop a firm-level understanding of revealing, the multi-level aspect was beyond the scope of this study.

APPENDIX A – INTERVIEW GUIDE

Protocol No: 018444

Project title: **Knowledge sharing in innovative firms**

Interview questions

Org:

1. What is your main product?
2. Who are your competitors?

Background (personal):

3. What is your role in the organisation?
4. What are the innovation projects you are/were involved in? Can you describe the projects from the perspective of knowledge sharing?
5. Are you involved in any forms of open knowledge sharing (open sharing) with external parties?

Knowledge:

6. What kind of knowledge (e.g. IP) are shared and how? Can you provide some Examples?
7. How do these examples (knowledge sharing) relate to and impact your organisation?
8. *Are there any knowledge/IP that that is not shared openly? If so, why?

Drivers (+/-):

9. Is it (strategically) important to share the knowledge/IP? What were the benefits? can you provide examples?
10. Are there any barriers/challenges that prevented/limited your sharing activities/contents? How did you manage such barriers/challenges? If you did/could not, why?

Mechanisms:

11. How are the knowledge shared?
12. Can you provide examples for events/activities that are/were used to share knowledge?

Capabilities and culture:

13. Were there any skills/expertise (e.g. academic writing skills) required for any knowledge sharing activity?
14. Were they internally available? If not, how were they obtained?
15. Is knowledge sharing encouraged in the organisation (internally/externally)? If so, how?

Outcomes:

16. Were/are there any immediate benefits of knowledge sharing?
17. Are benefits of knowledge sharing evaluated in anyway?
18. Any examples for where there were any unexpected outcomes (good or bad) of sharing?
19. How do any of the benefits/outcomes of past sharing activities impact the organisation? Can you elaborate with an example?
20. How do you make sure that you don't get adverse outcomes? Manage risks? Examples?

APPENDIX B – OBSERVATION SCHEDULE

Protocol No: 018444

Project title: **Knowledge sharing in innovative firms**

Observation schedule

Observation will be used to enrich the data gathered through interviews by attempting to understand the organisational culture and practice of open sharing as much in detail as possible. The observations will be unstructured and qualitative in nature and will depend on the event/activity observed. Therefore, the following is only illustrative and may vary depending on the context.

The events/activities that are observed will be directly involved in open sharing. Examples of such events /activities may include;

- Internal meetings to discuss knowledge sharing requirements/objectives/methods/tools specific to the projects
- Specific meeting with clients/collaborators to brainstorm, plan and blueprint the knowledge sharing activities (e.g. writing journal articles, planning communications campaigns)
- Events that are conducted to share knowledge with external parties (workshops/presentations/training sessions)

Key points of observation

General setting
• Location
• Infrastructure/material in place
• Number of participants
• General profiles of the participants (role, expertise) – if observable/known
• Atmosphere of the setting
• Facilitators of the event/activity (profile, expertise, tasks)
Flow of the event
• Objectives/purpose explained
• Language used to communicate (semantics, simplicity/complexity, tones, etc.)
• Key decisions presented (if meeting)
• Decisions made (if meeting)
• Task allocations (who is doing what) in sharing activities
Culture
• Attitudes towards sharing
• Response to discussions/questions/requests

(based on: Lewis-Beck, M. S., Bryman, A. & Futing Liao, T. (2004). The SAGE encyclopaedia of social science research methods: SAGE Publications Ltd)

APPENDIX C – PARTICIPANT INFORMATION FORM

BUSINESS SCHOOL
DEPARTMENT OF MANAGEMENT
AND INTERNATIONAL BUSINESS

[Date]

Owen G Glenn Building,
12 Grafton Road
Auckland, New Zealand
T + 64 9 373 7599
W business.auckland.ac.nz
The University of Auckland
Business School
Private Bag 92019
Auckland 1142
New Zealand

Dear [Name]

PARTICIPATION INFORMATION SHEET (PARTICIPANT)

I am Saumya Amarasinghe, a doctoral student at the Department of Management & International Business (MIB), University of Auckland. I am currently conducting a research for my PhD on exploring the resource sharing practices of innovative firms. My PhD is supervised by Professor Kenneth Husted (Professor of Innovation and Research Management) and Dr. Frank Siedlok (Lecturer), who are also from the Department of MIB.

Innovation has become the strength of most firms in today's fast changing business world. Innovations both require and produce unique knowledge. My study aims to explore how and why innovative firms share internally developed knowledge in public or with selected external partners in the innovation process. This study aims to understand the motivations of the firms, activities carried out and the potential benefits related to such knowledge flows.

You are invited to participate in this project. Your organisation has granted us permission to approach staff members involved in the process of openly sharing internal knowledge. You are selected because you are currently working or have worked on innovation projects that involved/involves sharing knowledge openly with outsiders. If you are interested to participate in this project, please contact the researchers directly.

Project procedures:

We will be gathering information via interviews and by observing specific events relevant to knowledge sharing activities. As a participant you may be involved in either interviews only or both of these information gathering techniques. The management of your organisation has given their approval to conduct the interviews during work hours.

We will be conducting up to two interviews with you over a four week period. Depending on the data analyses conducted on your responses in the first interview, we will decide whether the second interview is necessary. The interviews will take approximately 1.5 – 2 hours. Any personal details that may be gathered in the course of this project will be dealt with confidentially. No personal information about you will be disclosed to third parties. You will not be identified in any publication of these research results. Therefore, identity of any individual responses quoted in the publications will be kept confidential.

We will be observing specific activities that are relevant to the knowledge sharing process of which you may be an attendee. Such activities may include any meetings, workshops or training sessions that are directly related to the knowledge sharing activities of the organisation. If you are a

potential attendee you will have the option to express your concerns about observation prior to the event directly to the researcher. No personal information will be gathered during observations and any information gathered during observations are kept confidential at all times.

Your participation in this study is voluntary. Your principal/owner/Chief Executive Officer has assured that participation or non-participation in this project will not affect your existing employment status in any manner. No individual responses will be shared with principal/owner/Chief Executive Officer or any other member of your organisation. Instead, if requested, we will provide a presentation or workshop in your organisation to communicate the findings of this study.

Data storage/retention/destruction:

Digital audio recorders may be used during the interview process. You can have these recording devices turned off at any point without giving a reason. We will transcribe the recordings, where necessary. You will have the opportunity to inspect the transcripts and suggest amendments if there are inaccuracies within 2 weeks of receiving the transcripts. Recordings and transcriptions will be kept securely in digital format at the premise of the University for 6 years. Access to the archived digital recordings and transcriptions will be restricted to the researchers of this project. After the prescribed period of storage, the digital data will be erased, and hardcopy, if any, sent to destruction agency for disposal in a confidential manner.

Future use of data:

The data will be used in the preparation of PhD thesis of the student, public seminars, media releases, materials for teaching, journal publications, book publications, business cases, and other research outputs deemed appropriate. No personal information will be published in any manner and your organisations and staff will not be distinguishable.

Right to Withdraw from Participation:

You are free to withdraw from participation in this project at any point without furnishing a reason, and with no consequences. However, any withdrawal of information provided via interviews may have to be done within 2 weeks of the first interview. If you wish to withdraw data within 2 weeks after a second interview is conducted, please note that you may be able to withdraw only the information provided at the second interview. The information provided at the first interview may not be withdrawn due to those being already processed and analysed, and a complete withdrawal of information may not be feasible.

Thank you very much for your time to consider this study. There is a consent form attached to this information sheet. This form is to gain your consent to your participation in the study. Your participation in the research would be greatly appreciated.
If you have any queries or wish to know more, please feel free to contact us using the details provided below.

Researcher: Ms. Saumya Amarasinghe, Dept. of Management & International Business, University of Auckland Business School, New Zealand, Email: s.amarasinghe@auckland.ac.nz

Supervisor: Prof. Kenneth Husted, Phone: +64 9 373 7599 Ext. 86829, Email: k.husted@auckland.ac.nz

Co-supervisor: Dr. Frank Siedlok, Phone: + 64 9 373 7599 Ext. 82744, Email: f.siedlok@auckland.ac.nz

Head of the department: Prof. Rod McNaughton, Phone: +64 9 923 7524, Email: r.mcnaughton@auckland.ac.nz

For any queries regarding ethical concerns you may contact the Chair, The University of Auckland Human Participants Ethics Committee, The University of Auckland, Research Office, Private Bag 92019, Auckland 1142. Telephone 09 373-7599 ext. 83711. Email: ro-ethics@auckland.ac.nz

APPROVED BY THE UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS ETHICS COMMITTEE ON 19/06/17 FOR THREE YEARS. REFERENCE NUMBER 018444.

APPENDIX D – CONSENT FORM

BUSINESS SCHOOL
DEPARTMENT OF MANAGEMENT AND INTERNATIONAL BUSINESS

Owen G Glenn Building,
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T + 64 9 373 7599
W business.auckland.ac.nz
The University of Auckland
Business School
Private Bag 92019
Auckland 1142
New Zealand

CONSENT FORM (PARTICIPANT)

THIS FORM WILL BE HELD FOR A PERIOD OF 6 YEARS

Project title : **Knowledge sharing in innovative firms**

Names of researchers : Kenneth Husted, Frank Siedlok and Saumya Amarasinghe

I have read the Participant Information Sheet; have understood the nature of the research, and why I have been selected. I have had the opportunity to ask questions and have them answered to my satisfaction.

- I agree to take part in this research
- I understand that I am free to withdraw participation from the study at any time.
- I understand that I am free to withdraw any information provided via interviews within 2 weeks after the first interview is conducted. If in case of withdrawal within 2 weeks after the second interview, I understand that I can withdraw only the data provided in the second interview.
- I understand that my organisation has provided permission to the researchers to access my organisation's facilities and staff, conduct interviews and to observe specific events during work hours
- I understand that my principal/owner/Chief Executive Officer has assured that participation or non-participation will not attract any repercussions or affect my existing employment status
- I understand that confidentiality will be maintained at all times
- I understand that personal information, if any, collected from this study will be treated confidentially
- I understand that quotations from individual responses may be used in publications, but the identity of the respondent will not be distinguishable.
- I understand that there is an option to request for a presentation or workshop that will communicate the findings of this study
- I agree / do not agree to be audiotaped for the interview. (Even if you agree to being recorded, you may choose to have the recorder turned off at any time)
- I understand that I can request a copy of the final transcription and recommend amendments if there are inaccuracies within two weeks of receiving the transcripts
- I understand that data collected will be used for teaching and research purposes as set out in the Personal Information Sheet, and deemed appropriate by the University
- I understand that interview responses, transcriptions, and digital recordings may be kept for 6 years, after which they will be destroyed

Name_____ Signature _____Date _____

APPROVED BY THE UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS ETHICS COMMITTEE ON 19/06/17 FOR THREE YEARS. REFERENCE NUMBER 018444.

APPENDIX E – SUMMARY OF FINDINGS ACROSS THE FIVE FIRMS

Firm	Revealing behaviour	Mechanisms	Drivers	Capabilities	Strategic Actions
EVD	Extreme revealing	Publications (incl. technical, practitioner, internet based); Training workshops and conference presentations; Open-source databases.	Ideological drivers - Openness being a core founding value of the firm - Revealing to create social/environmental impact Induce Industry advancement - Establish operational best practices in the industry - Revealing ongoing work to avoid repetitive R&D - Desire to fill technical knowledge gaps in the industry	Codification of knowledge - Academic training to codify knowledge - Simplifying complex knowledge for a general audience Presentation of knowledge - Ability to use a variety of communication platforms Making knowledge selectable - Ability to modularise knowledge Prudent management of revealing process *Having a long-term action plan for the* revealing *activities*	Enhancing reach - Positioning knowledge in the appropriate user domain - Timing revealing activities with relevant external events for higher awareness Enhancing reusability - Peer validation of knowledge before revealing - Presentation of knowledge for optimum reuse
LMO	Extreme revealing	Open source contribution; Publications (internet based); Workshops & conferences (incl. online discussion forums).	Ideological drivers - Openness being a core founding value of the firm - Revealing to create social/environmental impact	Codification of knowledge - Simplifying complex knowledge for a general audience Presentation of knowledge - Ability to use a variety of communication platforms Making knowledge selectable - Ability to modularise knowledge Prudent management of revealing process *Adjusting* revealing *techniques based on requirements at the time*	Enhancing reach - Positioning knowledge in the appropriate user domain Enhancing reusability - Peer validation of knowledge before revealing - Presentation of knowledge for optimum reuse
SMX	Content-controlled	Scientific publications and conferences; Patents.	Induce industry advancement - Establish operational best practices in the industry - Revealing ongoing work to avoid repetitive R&D - Desire to fill technical knowledge gaps in the industry	Codification of knowledge - Academic training to codify knowledge Making knowledge selectable - Having internal IP management protocol to define disclosable knowledge - Ability to modularise knowledge	Internal knowledge preparation - Conducting internal reviews to avoid disclosing critical knowledge - Classification of knowledge for effective identification and management Enhancing reusability - Peer validation of knowledge before revealing

Firm	Revealing behaviour	Mechanisms	Drivers	Capabilities	Strategic Actions
	Access controlled	Collaborations incl. visiting facilities, exchange of personnel	For internal advancement - To source knowledge or capabilities for internal innovation - As an image building exercise – for reputation and validation - Create delayed revenue models	Managing risks of over-sharing - Identifying risk-reward balance in revealing activities - Establish contracts and guidelines for revealing through prior experience	Internal knowledge preparation - Conducting internal reviews to avoid disclosing critical knowledge - Classification of knowledge for effective identification and management Diligent collaboration management - Use of formal and informal guidelines to conduct initial talks with partners Use of agreements and trust building during collaborations
RQL	Restrictive behaviour	Restrictive partnerships; Scientific publications; Patents; Collaborations incl. visiting partner facilities, materials exchange.	For internal advancement - To source knowledge or capabilities for internal innovation - As an image building exercise – for reputation and validation - As a defensive strategy to claim ownership of knowledge - Create delayed revenue models	Codification of knowledge - Academic training to codify knowledge Making knowledge selectable - Having internal IP management protocol to define disclosable knowledge - Ability to modularise knowledge Managing risks of over-sharing - Identifying risk-reward balance in revealing activities - Identifying, evaluating and efforts to understand partners - Establish contracts and guidelines for revealing through prior experience Prudent management of revealing process - *Contingently adjusting the disclosure rules for knowledge modules*	Internal knowledge preparation - Conducting internal reviews to avoid disclosing critical knowledge - Classification of knowledge for effective identification and management Diligent collaboration management - Use of formal and informal guidelines to conduct initial talks with partners Use of agreements and trust building during collaborations
TTR	Restrictive behaviour	Collaborative development; Scientific publications; Patents.	For internal advancement - To source knowledge or capabilities for internal innovation - As an image building exercise – for reputation and validation - As a defensive strategy to claim ownership of knowledge	Codification of knowledge - Academic training to codify knowledge Making knowledge selectable - Having internal IP management protocol to define disclosable knowledge - Ability to modularise knowledge Managing risks of over-sharing	Internal knowledge preparation - Conducting internal reviews to avoid disclosing critical knowledge - Classification of knowledge for effective identification and management Diligent collaboration management

Firm	Revealing behaviour	Mechanisms	Drivers	Capabilities	Strategic Actions
			- Create delayed revenue models	- Identifying risk-reward balance in revealing activities - Identifying, evaluating and efforts to understand partners - Establish contracts and guidelines for revealing through prior experience	- Use of formal and informal guidelines to conduct initial talks with partners Use of agreements and trust building during collaborations

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