# A multi-level exploration of learning and knowing for innovation in an emerging biotechnology industry.

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# Abstract

Innovation in disciplines, sectors, nations, regions and clusters has received considerable attention from innovation scholars. Yet, despite scholars' efforts to examine innovation at these macro levels of the innovation system, there remains a gap in explaining innovation at the more micro-levels. This thesis explores influences on firms' and individuals' practices of accessing expertise for innovation. Findings of my research contribute towards new understandings about innovation at the more micro-levels of firms and individuals.

Drawing together gaps in the existing organisational learning, organisational knowledge, and innovation literatures, and the research problem faced by biotechnology firms in an emerging industrial cluster in Auckland, New Zealand, two research questions are posed:

1. *What obstacles do biotechnology firms in emerging industrial clusters face to accessing expertise for innovation?*
2. *How are individuals' search and selection practices for firms' innovation influenced by geographic and relational location?*

The research model is developed and operationalised in four intellectually related research studies that are reported as independent research papers. The first research question is addressed by two studies. The first study uses a system of innovation perspective that recognises disciplines in the form of norms regarding roles in the innovation system and the national innovation system in the form of New Zealand's knowledge-based development. These perspectives are used to examine organisational actors' participation in public debates about biotechnology. The second study examines how interactive learning in the innovation system and knowledge-based development influence firms' knowledge processes in the form of communication channel use.

The second research question is addressed by two studies using a practice-based view that recognises the situated nature of learning and knowing. One study focuses on individuals' search practices for innovation and explores how these are influenced by firms' geographic and relational location and emergent cluster life-stage. The other study concentrates on individuals' selection practices for innovation and explores when and why varying forms of geographic and relational location influence them.

# Dedication.

In Memory of Isobella Judith May Callagher

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"While it takes a village to raise a child, it takes communities to complete a PhD".

(Callagher, L. December 13, 2010).

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# 1 INTRODUCTION

This chapter introduces the research problem and outlines the thesis that addresses it. I start by describing the recent history of biotechnology in New Zealand, including government efforts to facilitate a biotechnology cluster in Auckland, the country's largest city. This context is important to understanding the research problem and research questions. Next, I summarise different explanations from the literature about innovation in the biotechnology industry. Together, the ongoing issues faced in the New Zealand context and the theoretical issues discussed in the literature motivate two research questions. In order to address the research questions I identify and outline theoretical perspectives from the organisational learning, organisational knowledge, innovation theories, and, management perspectives literatures that inform the research questions. Following that I summarise the research design used to address the research questions. Finally, I set out the structure for the rest of the thesis, concluding with summaries of the four studies.

## 1.1 Biotechnology and the Auckland, New Zealand context

Human beings have long demonstrated a desire to manipulate nature to create new products and improve existing ones. For instance, brewers in Babylon and ancient Egypt tinkered with micro-organisms in their brewing of beer; scientists in Germany developed large-scale yeast production methods that met 60% of animal feed needs during World War I, and, Scottish scientist Alexander Fleming discovered the anti-bacterial properties of penicillin in 1928. However, discovery of the structure of DNA in 1953 by Crick and Watson, research on single-cell proteins during the 1960s, and, development of a recombinant DNA technique in 1973 by Cohen and Boyer opened new windows of opportunity for manipulating nature, which are commonly referred to as biotechnology (Bud, 1994).

Biotechnology can be defined as

> "the application of science and technology to living organisms, as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services" (OECD, 2005).

Not only does biotechnology present exciting opportunities for manipulating nature through advanced scientific knowledge processes, it also presents attractive commercial opportunities for developing new products, services and even markets (Pisano, 2006a). However, the uncertainty and complexity associated with biotechnology also presents some caveats to its commercial attractiveness.

Biotechnology is underpinned by the scientific knowledge production process whose future new knowledge cannot be known, so is impossible to assess. This leads to high levels of uncertainty in the innovation process that commercialises biotechnology (Pisano, 2006a). In regard to complexity, biotechnology is highly complex involving expertise across a number of scientific and commercial knowledge domains (Pisano, 1991; Powell & Brantley, 1992). Expertise refers to the specialised skills and knowledge that individuals bring to the task. Expertise is situated in knowledge domains and cultural fields where skills and knowledge are used (Bourdieu, 2005; Brown & Duguid, 1991).

Knowledge domains in the scientific process where basic research produces new scientific breakthroughs can include: genetics, microbiology, animal cell culture, molecular biology, bio-chemistry, embryology, cell biology, chemical engineering, bio-process engineering, bio-informatics and bio-robotics. Knowledge domains involved in the commercialisation process that develops scientific concepts into products and services can include: investors, competitors in the form of pharmaceutical companies and other biotechnology firms, regulatory agencies, research hospitals for clinical trials, manufacturing control and monitoring, and, marketing firms (Pisano, 1991, 2006b).

When these scientific and commercial inputs are considered together, the overall level of complexity across the innovation process is very high and beyond the capabilities of most individual organisations. Furthermore, the costs associated with developing that expertise can be uneconomic because the time taken to develop expertise is long and there is a high

risk that knowledge learned will be made redundant by new developments (F. Murray, 2001). Given this situation, biotechnology firms look to access expertise for their innovation from other organisations, rather than acquiring the expertise themselves (R. Grant & Baden-Fuller, 2004; Powell, Koput, & Smith-Doerr, 1996).

Despite high levels of uncertainty and complexity governments in many countries have pursued the development of biotechnology as part of the innovation system (OECD, 2006). Attracted by expectations of economic growth through high-technology start-up firms, and development of related services and increased knowledge-based employment, many governments have pursued public policies that promote innovation in biotechnology. In 2001 the New Zealand government took a similar stance, using Research, Science and Technology, Industrial and Economic Development, and, Tertiary Education policies to facilitate a biotechnology industry in New Zealand, including an industrial biotechnology cluster in Auckland (New Zealand Office of the Prime Minister, 2002).

The focus on developing the Auckland cluster reflected the existing concentration of biotechnology knowledge workers. These included *Genesis Research and Development*, the first registered New Zealand biotechnology company as well as 18 of the country's 39 core biotechnology firms (BIOTENZ & NZTE, 2003). Three of the country's eight state-funded universities are based in, or have large campuses, in Auckland, with two of them based in the city's central business district. Auckland is also New Zealand's commercial centre with a number of professional service firms providing accountancy, management consultancy and legal services. However, while some of the expertise needed for turning scientific breakthroughs into commercial products and services was available in Auckland; other critical forms of expertise were less accessible.

In mid-2006 when I began initial preparation for the PhD research, industry, government and universities had recognised that existing science and commercialisation capabilities needed to be expanded and that additional expertise, such as regulatory and clinical trial knowledge, had to be developed for the local industry. In response to this a number of initiatives were launched, including an industry-university project to develop a Biotechnology Community of Practice.

The aims of the Biotechnology Community of Practice were to 1) make already locally available expertise more accessible, and 2) address gaps in local expertise (Kistler & Husted,

2005). Informed by Wenger, McDermott, and Snyder's (2002) theory that communities of practice facilitate learning and innovation in organisations, the leaders of the project recognised that a community of practice might address a number of constraints to industry growth. However, communities of practice have been conceptualised as spatially constrained with their success depending on "their ability to design themselves as social learning systems and also to participate in broader learning systems such as an industry, a region or a consortium" (Wenger, 2003 p. 76). Given the emerging nature of biotechnology in New Zealand, this motivated the research problem, *when innovation requires expertise from different knowledge domains, how do firms learn when there are few experts to learn from?*

## 1.2 Innovation in the biotechnology industry

Scholars have applied a number of perspectives to explain innovation in the biotechnology industry. Prevezer (1997) and Zucker, Darby, and Brewer (1998) argued that biotechnology firms are able to innovate because they co-locate near public science. Using econometric analysis and in-depth case studies, Zucker et al (1998) found strong localised spill-over effects between universities and start-up firms. Based on agglomeration patterns they argued clustering near universities was necessary to new biotechnology firms' ability to innovate.

Looking beyond the role of public science, Audretsch (2001) argued that innovation by biotechnology firms depends upon what science commercialisation processes are facilitated in the region. Examining the career trajectories of pioneers and subsequent followers to the US biotechnology industry, Audretsch found that firms clustered in regions that enabled scientists to pursue commercial ideas and supported commercialisation through the presence of "venture capital and other forms of finance, the existence of an entrepreneurial culture, and transparent and minimal regulations fostering the start-up and growth processes"(2001 p. 3). He concluded that while strong science is a pre-condition for clustering, innovation in biotechnology firms requires other critical inputs.

Examining biotechnology in the German, UK and US innovation systems, Cooke (2002) argued the complex interactions among science and commercial processes are more effective

when performed in geographic proximity. Cooke (2002) proposed that regional systems of biotechnology innovation are more likely to provide the multiplicity of scientific and commercial expertise required to commercialise biotechnology products.

Recognising the importance of other inputs for biotechnology innovation, Powell et al (2002) examined the role of venture capital. Studying US venture capital investments over a ten-year period, they found young venture capital firms were more likely to invest in biotechnology firms in the same geographic region as the venture capitalist. Powell et al (2002) argued tacit knowledge sharing, face-to-face contact, and the ability to learn and manage across multiple projects are critical reasons for the continued importance of geographic propinquity in biotechnology innovation.

The effects of venture capital investment patterns on biotechnology innovation were also examined by Valentin, Jensen, and Dahlgren (2008). Comparing Danish and Swedish biotechnology clusters, they found that even when there is a sufficient investment presence venture capital firms' different strategies influence what types of projects secure deals and what commercialisation pathways are pursued.

Cooke (2001) argued the tendency of pioneering biotechnology firms to co-locate near quality science and venture capital presents challenges to new biotechnology clusters. Given the first US biotechnology clusters formed at least ten years before similar UK and European ones, he theorised that biotechnology firms in new industrial clusters have to compete with firms in established clusters to attract finance and knowledge workers.

Scholars using networking perspectives recognise that biotechnology innovation involves both local and non-local activities. Leibeskind, Oliver, Zucker, and Brewer (1996) argued that biotechnology innovation can be explained by the social networks that firms form with scientists and universities. Examining two highly successful new biotechnology firms, Leibeskind et al (1996) found the firms built multiple relationships with different organisations for learning purposes. Furthermore, these relationships were mainly governed through informal arrangements, such as norms and personal trust, rather than formal contracts.

Powell, Koput, and Smith-Doerr (1996) argued that networks are important for biotechnology innovation because they facilitate collaboration that provides firms with access to knowledge and interorganisational learning. Examining the social networks of a

sample of biotechnology firms from Boston over a five-year period, they found that firms' ability to form research and development alliances and gain experience in managing inter-firm relationships enhanced firms' network position, rates of growth, and portfolios of collaborative activities.

Owen-Smith and Powell (2004) used a networking perspective to explore the effect that geographic propinquity and organisational form has on innovation in human therapeutic biotechnology firms located in the Boston metropolitan and regional areas. Arguing spillovers that result from proprietary alliances are a function of the institutional commitments and practices of members of the network, they found linkages among physically proximate organisations provided effective communication channels that transfer rich local information. Furthermore, information received through these channels was found to have a direct impact on firms' innovation performance.

The notion that learning in networks influences biotechnology innovation was also argued by Coenen, Moodysson, and Asheim (2004). Examining knowledge dynamics through a database-survey of 109 biotechnology firms in Medicon Valley, the Danish-Swedish life-science cluster, Coenen et al (2004) demonstrated dual local-global knowledge flow patterns as firms connected to local nodes of excellence that acted as connectors to global nodes. These scholars argued the nodes of excellence played a boundary spanning role that provides relational proximity within the epistemic communities involved in biotechnology innovation. Furthermore, they concluded relational proximity in biotechnology requires closer consideration by innovation management scholars.

Although these scholars have provided important insights into the relationship between biotechnology firms' innovation and the wider innovation system, there are some gaps in the literature. Studies of biotechnology clusters rarely consider the life-stage of the industrial cluster. This makes it difficult to draw inferences about innovation in newly emerging clusters, such as the Auckland one, from the existing literature because the characteristics of emerging clusters are different to those of growing, maturing and declining clusters (Menzel & Fornahl, 2010).

When scholars have examined the evolution of biotechnology clusters they tend to concentrate on the original clusters, such as San Francisco and Boston. However, it is problematic to compare newly emerging clusters to these well established ones because

newly emerging clusters face more competition to attract new start-up firms, venture capital and knowledge workers. Furthermore, scientific knowledge has rapidly advanced since the original clusters were established, making it even more difficult for newly established clusters to provide all local expertise within a single location.

Networking perspectives provide one explanation of firms' innovation in biotechnology. These scholars suggest that firms can secure knowledge resources for innovation by developing local and non-local ties to a range of organisations. While these theories are useful to understanding why biotechnology firms use social networks and the effect networking has on firms' innovation performance, this body of literature is not forthcoming about the learning and knowledge processes that occur through networking. The assumption that knowledge is "out there" for firms to acquire (Lechner & Dowling, 2003) is especially problematic for understanding how firms access expertise from knowledge domains they are unfamiliar with.

A further limitation to the cluster, regional systems and network explanations of innovation in biotechnology is their limited consideration of the role of the individual. While firms, clusters, regions and networks are important in the biotechnology industry, analysis of individuals' action is equally important because innovation occurs through large numbers of local events and interactions of everyday life in organisations (Johannessen & Aasen, 2007). Furthermore, it is the individual employee whose expertise is used during innovation (Lorentzen, 2007).

## 1.3 Research Questions

Given these gaps in the existing literature and drawing together the research problem faced by biotechnology firms in Auckland, New Zealand, two question questions are posed.

Recognising that industrial cluster life-stage, interactive learning in the innovation system and knowledge-based development are likely to influence firms' learning and knowledge processes as they access expertise for innovation,

1. *What obstacles do biotechnology firms in emerging industrial clusters face to accessing expertise for innovation?*

Motivated by findings to the first research question, process of innovation models, and, the practice-based view of learning and knowing,

2. *How are individuals' search and selection practices for firms' innovation influenced by geographic and relational location?*

## 1.4 Theoretical perspectives that inform the research

Since accessing expertise is important for firms' innovation, it is necessary to establish existing explanations about it from the organisational learning, organisational knowledge and innovation literatures. In these well established bodies of literature scholars have theorised learning, knowledge and innovation processes at many levels of analysis. For this particular research it is more relevant to draw on theoretical perspectives that appreciate the role of the individual and the firm in these processes, as well as the wider context in which these processes occur. Examples of such perspectives include the practice-based view of learning and knowing, systems of innovation, and processes of innovation.

Recognising organisational learning, organisational knowledge and innovation as well established topics, I undertook to two survey-type literature reviews. According to Huff (2009) the purpose of survey-type literature reviews is to establish the nature of the topic and its key issues through routinely engaging with a wide range of fields or disciplinary perspectives. A survey approach to my reviews is relevant because there has been a substantial amount of scholarship on these topics from a range of perspectives. Furthermore, the multidisciplinary nature of innovation makes a survey-type review appropriate to establishing a comprehensive picture of the topic under investigation (Gopalakrishnan & Damanpour, 1997; Pavitt, 1999).

Through a broad reading of review articles, journal special issues and handbooks from organisational studies, management, organisational economics, technology management, economic geography and sociology, my literature survey revealed a number of theoretical perspectives that contribute towards a research model to address the research questions. These perspectives include: cluster life-cycle stage, interactive learning in the innovation

system, knowledge-based development, practice-based view of learning and knowing, and search and selection processes for firms' innovation.

### 1.4.1 Cluster life-cycles.

Menzel and Fornahl (2010) theorised that industrial clusters experience a four-stage life-cycle of emergence, growth, decline and renewal. According to their model emerging clusters, such as the biotechnology cluster in Auckland, New Zealand, are characterised by young knowledge-based firms in the early stages of development. Typically emerging clusters have few firms with a lasting vision for a new local technology path. They often have favourable local scientific and political conditions to support cluster growth to a critical mass, but experience a small skilled labour market due to few workers having been employed and heterogeneity of technology. These characteristics culminate in weak conditions for localised learning and knowledge processes because there are a small number of individuals and firms to learn from. Furthermore, those few actors are likely to share limited cultural fields due to a heterogeneity of technology (Menzel & Fornahl, 2010). By exploring the dynamics of the emerging cluster life-cycle stage, these characteristics can inform the challenges faced by biotechnology firms to gaining expertise in the cluster in Auckland, New Zealand.

### 1.4.2 Interactive learning in the innovation system

The second theoretical perspective that informs this research is the role of interactive learning in the innovation system. This is particularly useful for understanding biotechnology firms in the Auckland cluster for two reasons. First, the key issue that firms face is a learning issue of gaining expertise. Second, learning is the explicit agenda for some industry-university initiatives.

Starting from the premise that knowledge is the fundamental resource in modern society, Lundvall (1992) claimed that interactive learning has become the key to firms' performance because it is crucial to firms' knowledge acquisition from the wider innovation system (Edquist, 1997) Taking a broad definition of learning as including practical skills established

through learning by doing, new insights produced by R&D, as well as capabilities acquired through formal education and training, Lundvall and Borras (1997) argued that learning leads to growth in the stock of knowledge that support firms' innovation. Interactive learning is useful because it explains organisations' actions regarding learning in the innovation system. Furthermore, it draws attention to the fact that organisations contribute different learning to the innovation system due to the different institutions that influence them. This is particularly valuable when biotechnology innovation is considered as integrating both scientific and commercial processes.

### 1.4.3 Knowledge-based development

Recognising that global and local contexts interplay (Carrillo, 2009), it can be expected that an increasing heterogeneity of views and opinions will be promulgated in the innovation system. In response to complexity of knowledge based phenomena, the knowledge-based development approach proposes that in order to develop effective innovation systems it is necessary to understand the interaction among actors who are involved with transforming global knowledge into local development (Knight, 1995). This perspective is useful to exploring the nature of interactions between individuals, organisations and institutions involved in biotechnology, both in Auckland and New Zealand more broadly.

As well as exploring interactions between stakeholders, knowledge-based development proposes strategic action on the part of governments and their agencies to facilitate and co-ordinate processes for constructing a stronger knowledge base at national, regional and local levels (Mansell, 2002). Furthermore, knowledge-based development provides a framework for understanding why and how governments seek to influence dynamic knowledge-related processes (Carrillo, 2002). This can guide analysis of public policies used to foster a biotechnology industry in New Zealand and the influence these policies have on firms' innovation.

### 1.4.4 Search and selection processes for firms' innovation

Hargadon (2002) argued that individuals can have different knowledge brokering roles and learning intentions that affect their actions during firms' innovation. In some instances individuals learn in order to be recognised for their expertise in the context where their knowledge is applied. In contrast, individuals sometimes learn in order to work competently with others whose expertise from different knowledge domains can solve particular problems. This is useful to understanding the different intentions of individuals involved in accessing expertise for biotechnology innovation in Auckland, New Zealand.

Search and selection processes are especially important processes for firms' innovation because searching scans the internal and external environment to generate a requisite variety of opportunities and selection chooses what opportunities firms' will pursue from those identified (Van de Ven, 1986). These processes are likely to be even more important for firms in Auckland because of the limited expertise within the cluster. Given that individuals are important because innovation occurs through large numbers of local events and interactions of everyday life in organisations (Johannessen & Aasen, 2007), focussing on individuals' practices during search and selection processes is likely to inform individuals' roles in firms' innovation.

### 1.4.5 Practice-based view of learning and knowing

Where the other perspectives that inform this research concentrate on organisations and institutions in the innovation systems, the practice-based view of learning and knowing explains learning as both an individual and collective process that is inextricably linked to the context where learning takes place (Gherardi, Nicolini, & Odella, 1998; Lave & Wenger, 1991). This is useful for this research because the role of the individual in accessing expertise in the context of wider innovation systems has received limited attention in the literature.

From the practice-based view, learning and knowing are defined as cognitive and social processes "of participating with requisite competence in the complex web of relationships among people and activities" (Gherardi, et al., 1998 p. 274). Learning and knowing can be understood through practices, with changes to individuals' practices reflecting individual learning and knowing. Practices are patterns of human activities that are made up of 'doings

and sayings' (T. Schatzki, 2002). 'Doings' refer to things that people directly do with their bodies, such as waving, standing and touching and 'sayings' refer to communicating about something, such as through language.

Practices are contextually embedded in the sites where they are performed. Sites have been described as cultural fields, fields of practice and social worlds. Innovation in biotechnology requires expertise from many cultural fields. In order to access expertise individuals need to be able to participate in those different cultural fields. However, participation requires individuals to understand the field's norms, values and rules of thought and action (Coenen, et al., 2004). In some situations individuals need to be expert in the field, but in other situations being an adequate performer is sufficient. The notion of social worlds is especially useful in this research because it recognises that individuals have different types of membership to social worlds (D. Unruh, 1979). By exploring the practices of individuals working for biotechnology firms in Auckland, New Zealand, the role individuals' everyday activities within the wider innovation system can be understood.

## 1.5 Research Design

Given that firms' innovation is informed by cluster life-stage (Menzel & Fornahl, 2010) interactive learning in the innovation system (B. Lundvall & Borras, 1997), knowledge-based development (Carrillo, 2002), search and selection processes (Van de Ven, 1986) and individuals' practices (Gherardi, 2009a, 2009b), it was necessary for me to understand the history of biotechnology in New Zealand's innovation system, firms' practices in the Auckland cluster, and individuals' practices in those firms. Throughout the research my understanding of the practice-based view of learning and knowing for innovation and of biotechnology changed, so the results of the initial studies influenced my decisions regarding the choice and direction of subsequent studies.

Due to the exploratory and evolving research approach it can be difficult to outline a linear process that encapsulates the various data collection and analyses I undertook over the three-year period. Instead it can be more helpful to consider the overall research design as a series of studies. The studies stand independently in their own right, but each is

informed by decisions regarding subsequent ones. Most importantly, when considered together they address the research questions posed.

To address the research questions I collected seven sources of data. The data sources are; 1) newspaper articles, 2) exploratory interviews of industry stakeholders, 3) public policies, 4) conversations at industry events, 5) publicly available information, 6) interviews at case study firms, and, 7) company information from case study firms. Data collection and analysis happen in parallel with interpretation of the different data informing each other. Furthermore, I use a range of analysis techniques for the studies.

## 1.6 Outline of the thesis

The thesis is organised in this way. Following this introduction chapter (chapter one), I present the literature reviews. Organisational learning and organisational knowledge are reviewed in chapter two to consider various schools of thought and perspectives that contribute explanations of learning and knowing for innovation. Innovation theories and management perspectives are reviewed in chapter three. In particular, how innovation has been conceived as a process and how innovation scholars have explained the relationship between learning, knowledge and innovation are reviewed.

In chapter four, I outline the two research questions and research model that are informed by the literature reviews and the research problem. The research model is operationalised in four intellectually related research studies that are reported as independent research papers. The methods used in the thesis are explained in chapter five. Chapter five includes the exploratory and evolving research approach, the data sources and methods for collection, and, the analysis techniques used in the four studies. Chapters six to nine present the four studies – summaries of the studies are outlined in the next section (see Figure 1.1 for summary of the studies and research questions they address). Finally, chapter ten explains the contribution of the research to developing more micro-level explanations of learning and knowledge processes for innovation, and outlines the implications for innovation scholars, policy-makers, and future research.

**Figure 1.1: Summary of the research questions and studies.**

| | |
|---|---|
| RQ 1: 1.What obstacles do biotechnology firms in emerging industrial clusters face to accessing expertise for innovation? | Study 1. "The role of industry R&D in science medialization" (published in International Journal of Knowledge-Based Development) |
| | Study 2. "Exploring firms' responses to innovation policy: evidence from an emerging biotechnology cluster" (working paper) |
| RQ 2: How are individuals' search and selection practices for firms' innovation influenced by geographic and relational location? | Study 3. "Searching near and far: a practice perspective of knowledge access in emerging clusters" (accepted to International Journal of Entrepreneurship and Innovation Management) |
| | Study 4. "Locations of innovation and their influence on partner selection practices" (published in Australia and New Zealand Academy of Management Conference proceedings) |

**Study 1**

In "The role of industry R&D in science medialization" (published in *International Journal of Knowledge-Based Development*), my co-author and I examine whether the extent of medialization of biotechnology is associated with the particular roles of actors in the national innovation system. Applying three dimensions of medialization - extensiveness, pluralization and controversy, to a stratified sample of newspaper articles from 1995-2009 inclusive, we find low levels of medialization of biotechnology compared to studies of other countries. Philosophy of science scholars have theorised an increasing interaction among science policy, public science and private R&D regarding public debates about the direction and priority of science in the society (Etzkowitz & Leydesdorff, 2000; Gibbons et al., 1994). However, we find that private R&D continues to be reported using the traditional economic frame and New Zealand universities continue to be reported in with the traditional scientific frame. The frames used to report public research organisations have diversified, but the extensiveness has fallen over the 15-year period. These longitudinal trends suggest that organisational actors who are central to developing a New Zealand biotechnology industry continue to act within their traditional fields of practice.

**Study 2**

In my working paper, "Exploring firms' responses to innovation policy: evidence from an emerging biotechnology cluster", I examine firms' responses to various public policy attempts at facilitating innovation. Focussing on the ways that innovation policy stimulated firms' communication practices associated with knowledge production and knowledge sharing, I find that biotechnology firms mainly rely upon face-to-face and pipeline communication channels for their innovation activities. My findings also show that pipelines, which are strategically focussed extra-local linkages (Asheim, Coenen, & Vang, 2007), were reported by participants as increasingly important as firms moved beyond early-stage research due to the lack of local expertise. While other scholars have reported biotechnology firms' use of local-global knowledge links (M. S. Gertler & Levitte, 2005; Franz Todtling, Lehner, & Trippl, 2006; F. Todtling & Trippl, 2007), this study suggests policy-makers revise innovation policy to support both local and global links as part of their efforts to foster emerging industrial clusters in regional innovation systems.

**Study 3**

In "Searching near and far: a practice perspective of knowledge access in emerging clusters" (accepted to *International Journal of Entrepreneurship and Innovation Management*), I compare search practices used at three biotechnology firms operating in an emergent cluster in New Zealand to search practices reported in the literature on established clusters. Comparing individuals' practices in the emerging cluster to those reported in extant literature, the study provides insights into how geographic proximity and cluster life-stage influence the practices that individuals use to search out local and non-local expertise. Comparing individuals' practices under varying relational proximity, experience-based differences were found. Individuals' different practices were explained using the Regulars and Strangers types in Unruh's (1979) participation typology.

**Study 4**

In "Locations of innovation and their influence on partner selection practices" (published in *Australia and New Zealand Academy of Management Conference proceedings*) I address how firms operating in an emergent industrial cluster adapt their practices for partner selection

to varying geographic and relational location while trying to innovate. My perspective in this study draws upon two bodies of theories, one around the geographic location of innovation and the other around the relational location of innovation. Drawing on these I argue that geographic and relational location of innovation does not operate in isolation; firms experience both forms of locational influence concurrently. By applying the conceptual matrix to firms in an emerging industrial cluster I explore when and why the different combinations of location influence individuals' partner selection practices. Studying selection practices used by individuals in three biotechnology firms I find that when relational proximity and geographic distance are present, firms create geographic temporary proximity. This is sufficient because the existence of shared ways of knowing individuals to work together using communication technologies. However, when relational and geographic distances are present, firms create geographic proximity because it is necessary to individuals learning ways of knowing in the other field of practice.

# 2 THEORIES OF ORGANISATIONAL LEARNING AND ORGANISATIONAL KNOWING

This chapter surveys the literature on organisational learning and organisational knowledge as important and interconnected topics that inform the research problem outlined in chapter one. That is, *when innovation requires expertise from different knowledge domains, how do firms learn when there are few experts to learn from?* Given the research problem, the aims of the chapter are to establish key organisational learning and organisational knowledge concepts that 1) inform the development of research questions which attend to the research problem, and, 2) guide the development of an adequate research model to address those questions.

According to Huff (2009) the purpose of a survey-type literature review is to establish the nature of the topic and its key issues through routinely engaging with a wide range of field or disciplinary perspectives. A survey approach to this review is relevant because there has been a substantial amount of scholarship on both topics from a range of perspectives. Through my broad reading in the organisational studies, management, economic geography and sociology fields, and consideration of review articles, journal special issues and handbooks on these topics, the intricate relationship between organisational learning and organisational knowledge can be established.

My survey-type review reveals that different schools of thought regarding organisational learning and different perspectives on organisational knowledge contribute several important concepts about learning and knowledge processes and the role of context for innovation. Furthermore, the practice-based view of learning and knowing is established as an appropriate theoretical perspective for studying these processes in context. Yet, despite the proliferation of theory some important issues remain.

An ongoing issue concerns how learning and knowing can be organised across geographic locations for innovation. A more recent issue concerns how firms might organise learning and knowing processes within and across knowledge domains whose boundaries

are not closely related. Furthermore, how geographic and relational location interact to influence learning and knowing presents a further issue that is especially important when knowledge is considered as a source of competitive advantage for firms and nations.

Given the aims of the chapter, the literature survey is presented in the following way. I begin the chapter by locating the practice-based view of learning and knowing in wider discussions about organisational learning and organisational knowledge. Since organisational learning and organisational knowledge are substantial topics in their own, it is useful to review them in separate sections. In section 2.2 three different schools of thought that are identified in the organisational learning literature are considered. The schools are reviewed to establish concepts that explain learning processes across individual, organisational and interorganisational levels and the role of context in relation to those processes. In section 2.3 two perspectives on organisational knowledge are reviewed to establish concepts that explain how knowledge is shared and the role of context in relation to knowledge sharing processes. Finally, in section 2.4 the practice-based view of learning and knowing and its precepts - *practices*, *sites of practice* and *membership in sites* – is explained to establish its usefulness for understanding the research problem. I conclude the chapter by re-stating the value of taking the practice-based view of learning and knowing.

## 2 Locating the practice-based view in organisational learning and organisational knowledge.

Since the 1980s organisational studies of learning and knowledge have been the subject of lively debate (Gherardi, 2009d). Initially introduced into the organisational studies literature by Simon (1957), March and Simon (1958) and Cyert and March (1963), the term 'organisational learning' gained traction in organisational literature towards the late 1970s. Traction followed the publication of Argyris and Schon's (1978) book *Organizational Learning* (Argyris & Schon, 1996). Growth in organisational learning research signalled an explicit interest in the subject, which over the following two decades generated a substantial body of work (Bapuji & Crossan, 2004; Easterby-Smith, 1997).

Scholars of organisational learning have made significant contributions regarding how learning is organised as part of wider workplace arrangements. Fiol and Lyles (1985) distinguished between organisational learning and organisational adaptation arguing that learning is more than adaption and requires firms' conscious attention. In providing a theory to focus firms' attention Huber (1991) described organisational learning as a process based on constructs of knowledge acquisition, information distribution, information interpretation, and organisational memory. Levitt and March (1988) stressed that organisational learning as a routine-based, history-dependent, and target-oriented process is informed by the organisation's memory on the one hand and the external environmental conditions on the other hand. Weick and Roberts (1993) proposed the notion of the collective mind to describe shared heuristics used by groups of individuals. Crossan and her colleagues (Crossan, Lane, & White, 1999; Crossan, Lane, White, & Djurfeldt, 1995) proposed intuiting, interpreting, integrating, and institutionalising as processes to explain the link between learning at the individual, group, and organisational levels. These contributions, and others, elevated organisational learning as an important process concerning firms' historical and future arrangements, involving internal and external contexts and connecting individual, group and organisational activities.

By the 1990s interest in organisational learning re-focussed towards notions of organisational knowledge and knowledge management (Gherardi, 2009b). Increased interest in knowledge coincided with debates about knowledge economy (Beck, 1992), knowledge society (Giddens, 1990), knowledge work (Drucker, 1993) and knowledge-based development (Carrillo, 1997) as responses to increasing competitive pressures.

Proposing the knowledge-based view of the firm in *Strategic Management Journal Special Issue*, a number of scholars (Conner & Prahalad, 1996; R.M. Grant, 1996a; R. M. Grant, 1996b; Spender, 1996a, 1996b) argued it is applied knowledge or 'know-how' embedded in organisational culture, rules and routines, and individual employees that provides long-term sustainable competitive advantage. These contributions focussed scholarly and practitioner attention on knowledge as a resource to be managed through organisational mechanisms.

In recognising knowledge as a critical organisational commodity scholars have contributed important theories regarding knowledge and firm performance. Nonaka (1994)

proposed a knowledge creation theory that linked individual knowledge to organisational knowledge through processes of socialisation, externalisation, combination and internalization.

A concurrent stream of research has been concerned with knowledge activities of firms in relation to wider systems of interaction. One type of interaction concerned firms' relations with customers, suppliers and competitors. These can be understood through industry life cycle and industrial clustering literatures that will be reviewed in the following chapter. Other types of interaction concerned relations with other stakeholders, such as public science and public policy. These can be understood through systems of innovation perspectives, which are reviewed in the next chapter also.

Other scholars recognised the challenges associated with using knowledge as a competitive resource. From eight case studies Szulanski (1996) described the difficulties of transferring best practices within firms due to tacit knowledge, which he argued makes knowledge 'sticky'. In studying the implementation of a new production technology into three different firms Tyre and Von Hippel (1997) argued stickiness of knowledge makes it difficult to share and challenging to manage. Carlile (2004) theorised that as novelty increases, the more demanding knowledge transfer becomes and illustrated this through a year-long ethnography of a new product development. In summary, these scholars highlight the problematic nature of knowledge sharing processes and their management in practice.

According to Gherardi (2000) organisational learning and organisational knowledge research agendas have been dominated by functionalist approaches to management. From the functionalist approach scholars assumed that learning is a cognitive process that resides in individual (Dodgson, 1993; Hedberg, 1981; H. A. Simon, 1991) or collective minds (Wegner, 1987; Weick & Roberts, 1993) to produce knowledge. As an object of strategic and economic value, knowledge is seen a transferrable between different entities as an outcome of learning (Cowan, David, & Foray, 2005; Prahalad & Hamel, 1990).

Some scholars challenge the functionalist approach by questioning the assumption that learning processes of individuals and organisations can be assumed as similar. Cook and Yanow (1993) argued there is no clear justification for extrapolating individualist cognitive constructs from psychology and management science to organisations because organisations do not have the cognitive mechanisms that humans do (i.e.: a brain). Nicolini and Menzar

(1995) cautioned that functionalist explanations under-theorise social aspects of learning and knowledge processes. Furthermore, Brown and Duguid (1991) pointed out that overlooking social aspects of learning is problematic because differences between formal descriptions of learning that are canonised in policies and procedures and the modus operandi of informal activities are ignored.

In moving away from the functionalist approach, a group of scholars has converged around constructivist and interpretive views of learning and knowledge. Recognising the importance of social processes to explaining how learning and knowledge is accomplished, these scholars concentrate on understanding the often incremental and mundane aspects of everyday life (de Certeau, 1984). This 'turn' to practice (T. R. Schatzki, Knorr-Cetina, & von Savigny, 2001) has been recently termed practice-based view of learning and knowing (Corradi, Gherardi, & Verzelloni, 2010; Gherardi, 2009a, 2009b; 2009c; 2009d).

Scholars of the practice-based view assume learning and knowing are both social and cognitive processes that involve actions of both mind and body. Because it recognises social context in which learning and knowledge occurs, the practice-based view complements dominant functionalist approaches that assume learning and knowledge are primarily cognitive actions.

To appreciate why the practice-based view can advance understandings of learning and knowledge processes in context, it is necessary to appreciate the different ways these topics have been conceptualised. In the next section, I review three schools of thought on organisational learning to establish why the practice-based view can provide a more nuanced understanding of organisational learning. My review of organisational knowledge in section 2.2 follows.

## 2.1 Conceptualising organisational learning

Organisational learning is a topic that is informed by a number of disciplines including psychology and organisational development, management science, strategy, production management, cultural anthropology and sociology (Easterby-Smith, 1997). These perspectives can be broadly categorised under three schools of thought that can be termed

the 'Individual learning-as-cognition' school, the 'Individual and organisational learning-as-cognition' school and the 'Individual and organisational learning-as-cognition-and-social' school. (Chiva & Alegre, 2005; Miner & Mezias, 1996; Popper & Lipshitz, 1998, 2000).

The different schools of thought have generated substantial bodies of theory regarding learning processes (Easterby-Smith, Crossan, & Nicolini, 2000). However, across these schools scholars make different assumptions about the nature of learning (Easterby-Smith, 1997). Given the different assumptions it might be difficult to integrate the various contributions into a single and coherent theory of organisational learning (Chiva & Alegre, 2005).

In addition to concerns about reconciling the different perspectives into a single and coherent theory, there are also issues regarding explanations of learning across levels of organisation. Some scholars writing on learning processes propose that transmission mechanisms are analogous across the individual, group (or team), firm and interorganisational levels (Weick & Roberts, 1993). However, whether transmission mechanisms used at the micro level (i.e.: individuals) can be applied at more macro levels (i.e.: groups or teams, firms and inter-organisations) might depend on assumptions made regarding the nature of learning (Antonacopoulou, 2006).

The idea that learning occurs across levels raises the matter of context and its role in those processes. Some scholars identify context as a variable that is external to the learning process, which can be controlled for (Crossan, et al., 1995), whereas other scholars identify context as an aspect that is central to understanding learning processes (Brown & Duguid, 2001). Given the differing viewpoints outlined above, it is useful to focus a review of the organisational learning literature along four dimensions:

1. Assumptions made regarding how learning occurs;
2. Concepts used to explain learning processes;
3. Concepts used to explain learning processes across levels; and,
4. How context is considered in learning processes.

### 2.1.1 'Individual learning-as-cognition'

The 'Individual learning-as-cognition' school of thought views organisational learning as primarily an individual cognitive process (Dodgson, 1993; Hedberg, 1981; J. March & Olsen, 1976; H. Simon, 1957) For example, Simon (1991 p. 125) argued that

> "all learning takes place inside human heads; an organization learns only in two ways: (a) by the learning of its members, or (b) by ingesting new member who have knowledge the organization previously did not have".

Assuming that organisational learning refers to individuals in organisations, the concepts used to explain learning focus on individual-level processes. Simon (1991) described internal learning as the process of transmitting information from one individual to another. Dodgson (1993) outlined the acquisition of knowledge, skills and attitudes as the process of individual learning. Dixon (1996) explained learning as the construction of individual meaning.

Given scholars from the 'Individual learning-as-cognition' school assume that organisational learning is an individual process, they do not propose explanations about how learning is transmitted from individuals to collectives. Instead, they concentrate on outlining organisational processes that facilitate individuals' learning. In particular these are focussed on human resource management practices that support individual learning processes of existing staff and recruitment of new labour (Popper & Lipshitz, 1998). For example, Simon (1991) noted training and socialisation tactics and Dodgson (1993) outlined encouraging and coordinating a variety of interactions as critical to facilitating internal learning between individuals.

The focus on organisational processes to support individual learning also recognises the role of context. From this perspective context is the background to individual learning and is important to the extent that it influences individual learning. Furthermore, context can be influenced through organisational processes, such as human resource management practices and socialisation tactics. However, the 'Individual learning-as-cognition' school's explanations of organisational learning are problematic for a number a reasons.

Duncan and Weiss (1979) criticised the individualist conceptualisation for its unsatisfactory explanation of how the organisational structures influence individuals' interpretation, communication and acceptance during learning. Popper and Lipshitz (2000)

went on to say explanations of organisational learning that focus on individual learning are difficult because they provide limited guidance of how individual learning mediates what organisations can do.

### 2.1.2 'Individual and organisational learning-as-cognition'

The 'Individual and organisational learning-as-cognition' school assumes that organisational learning is both an individual and collective process. Furthermore, this school of thought assumes that learning is primarily a cognitive process.

To explain organisational learning as an individual and collective process, scholars from the 'Individual and organisational learning-as-cognition' school identify individual-level concepts and apply them at the collective level of groups and organisations. For example, Argyris and Schon (1978) proposed individual and collective theories-of-action to explain how organisations learn. When individuals identify and correct errors in their cognitive maps double loop learning occurs (individual theories-in-action). This can also lead to changes to organisations' existing norms and assumptions (collective theories-in-action).

Similarly, Levitt & March (1988) and Walsh and Ungson (1991) theorised that routines act as organisations' memories because they capture the lessons of history. Using the concept of routines as an analogy to individual memory, these scholars argue that how organisations search for information is a consequence of memories. Routines make organisations' historical learning accessible to organisational members who did not experience that history directly.

Huber (1991) proposed that organisational learning can be understood as the processes of knowledge acquisition, information distribution, interpretation and organisational memory. Knowledge acquisition is concerned with how knowledge might be obtained through various forms of learning. Information distribution refers to how information from different sources is shared and understood. Interpretation relates to how commonly held understandings about information are developed. Organisational memory is defined as how knowledge is stored for future use.

Crossan and her colleagues (Crossan, et al., 1999; Crossan, et al., 1995) proposed intuiting, interpreting, integrating, and institutionalising as processes to explain the link between

learning at the individual, group, and organisational levels. Crossan, Lane and White (1999) defined individual learning as perceiving similarities and differences in patterns and possibilities for action. For them individual learning involves intuiting and interpreting as sub-processes. Intuiting refers to the process of recognising new insights from patterns built up through experience. Interpreting refers to refining and developing intuitive insights through communicating with others. Due to the difficulty of explaining intuition, Crossan et al (1999) argued that metaphors and imagery are used as communicating devices for sharing individual insights that cannot be explained with existing language (Morgan, 1997).

Crossan et al (1999) argued integrating and institutionalising processes embed individual learning in organisations' rules, procedures, routines and systems. Integrating refers to the process of developing shared understanding among groups of individuals and taking coordinated action through mutual adjustment. Institutionalising refers to the establishment of rules, procedures and routines that formalise the repeated actions of work groups. Furthermore, institutionalising is an organisational level process only because rules, procedures and routines endure independent of any one individual (Crossan, et al., 1999).

In terms of recognising context, some scholars within this school of thought acknowledge context as important to understanding organisational learning. For example, Crossan et al (1999) noted context as an important variable influencing intuiting, interpreting, integrating, and institutionalising processes in their theory. However, other scholars within this school do not note any role for context in explaining organisational learning.

Despite the contributions made by scholars from the 'Individual and organisational learning-as-cognition' school, there are some criticisms. These are related to 1) assumptions that individual learning processes can explain organisational learning, 2) use of hypothetical constructs to explain organisational learning, 3) assumptions that individuals' learning can be shared with other individuals, and, 4) limited concern for the influence of context on organisational learning.

Applying individual level concepts to the organisation as a way of explaining organisational learning is problematic because of anthropomorphism, or attribution of human qualities to non-human entities. This point was strongly made by Cook and Yanow (1993 p. 378) who argued that:

> "what organizations do when they learn is necessarily different from what individuals do when they learn. Specifically, we believe that organizational learning is not essentially a cognitive activity, because, at the very least, organizations lack the typical wherewithal for undertaking cognition. They do not possess what people possess and use in knowing and learning – that is, actual bodies, perceptive organs, brains and so forth. To understand organizational learning we must look for attributes that organizations can be meaningfully understood to possess and use".

In challenging the assumption that individuals and organisations have the same learning capacities, Cook and Yanow (1993) argued that it is more useful to conceive organisations as cultural entities rather than cognitive ones. They argued that a cultural perspective is required because it complements and extends current understandings of organisational learning of how groups of individuals take collective action. From this perspective, organisational learning can be defined as:

> "the capacity of an organization to learn how to do what it does, where what it learns is possessed not by individual members of the organisation but by the aggregate itself, that is, when a group acquires the know-how associated with its ability to carry out its collective activities, that constitutes organizational learning" (P. Cook & Yanow, 1993 p. 378).

The second criticism relates to the use of hypothetical constructs to denote the transmission of learning from individuals to organisations. For example, the concept individual mental model is used by some scholars to explain organisational learning through the creation of shared mental modes (Kim, 1993; Senge, 1990). Such an approach involves inferring the existence and nature of organisational learning with no way to empirically prove their existence (Popper & Lipshitz, 1998; Rouse & Morris, 1986).

The third criticism relates to the assumption that learning from individuals can be shared with other individuals and groups. Personal construct theory (Kelley, 1955) argues that individuals develop personal theories to explain their experiences. According to personal construct theory, the constructs that individuals build their theories upon are unique with individuals giving different meanings to the same concepts. People might use the same label

for a construct but its meaning will be unique to each individual (Kelley, 1955). According to personal construct theory, individuals' learning constructs are at best 'similar enough' to allow individuals to anticipate how others' will act, but not shared in any sense of being the same. Thus, asserting that individual learning constructs such as theories-of-action and mental models can be applied to organisational learning is problematic.

The fourth criticism relates to the limited way that scholars address context. Brown and Duguid (1991) argued that when abstracted from the context where they are practiced, concepts of learning are distorted or obscured. Relating their critique of functionalist organisational learning theories to work arrangements at the Xerox organisation, they proposed that 'learning-in-working' is best represented by closer examination of learning through practice. This call was elaborated by Blackler (1995) who criticised organisational learning scholars for paying scant attention to how knowledge is constructed and becomes consensual through social practices. Nicolini and Menzar (1995) went on to suggest that explanations of organisational learning can be advanced by recognising the role of context. Their reasons for this are elaborated under the next school of thought.

### 2.1.3 'Individual and organisational learning-as-cognition-and-social'

The 'Individual and organisational learning-as-cognition-and-social' school of thought assumes that organisational learning involves individual and collective entities. Furthermore, it does not accept the assumption that individual learning processes can be applied to collective entities. Strongly informed by sociology and cultural studies, these scholars presume organisational learning is a social-cultural process because organisations do not have a cognitive capacity that explains individual learning (Blackler, 1993; Kogut & Zander, 1992; Nicolini & Meznar, 1995).

**Individual Learning as cognitive and social processes.**

According to social learning theory individuals learn by observing, anticipating, imitating and modelling the actions of the people around them (Bandura, 1977). Being able to observe others' actions and anticipate what those actions symbolise requires a cognitive dimension to learning because individuals have to construct meanings from the actions they observe

(Bandura, 1986). In constructing meaning from observations, individuals must also anticipate how observations relate to prior and future actions. There is also a strong social dimension to accurately observing and anticipating the meaning of another's actions. This requires developing an understanding of the context in which those actions take place and anticipating how changes in context influence the meaning of observed actions (Bransford, Brown, & Cocking, 1999).

Accurately observing and anticipating the meaning of another's actions is only part of learning. Individuals must also accurately imitate and model those actions. This is a cognitive process of improving the accuracy of his/her imitation and it is a social process because modification of the individual actions is based on his/her prior experience and observation (Bandura, 1986). As the learner observes, anticipates, imitates and models different actions in different situations he/she develops personal constructs that enable him/her to recognise different patterns of action and adapt his/her actions to the context. In this way, individual learning is a social process as well as a cognitive one. Furthermore, context is central to understanding what and how individuals learn.

Similarly, Lave and her colleagues (Chaiklin & Lave, 1996; Lave & Wenger, 1991) theorised that learning is a situated activity whereby individuals learn by participating in communities of knowledgeable practitioners. They argued that in the social context of a community of practitioners, individuals construct their understanding of how people think and act. Furthermore, by participating individuals gain feedback on the acceptability of their actions in that situation.

From a perspective of learning as situated activity, learning is not just about developing declarative, procedural or abstract knowledge, it is also about learning how to act in the world in socially recognized ways (Bruner, 1996). This point was also made by Brown and Duguid (2001 p. 200) who claimed:

> "it is not enough to claim to be a physicist or a carpenter; people, particularly other physicists or carpenters, have to recognize you as such. People become managers or engineers not only by modelling themselves on managers or engineers (Ibarra 1999), but also by gaining the acceptance and recognition of managers or engineers. Learning, in all, involves acquiring identities that reflect both how a learner sees the world and how the world sees the learner".

According to Lave and Wenger (1991) access to situated activity requires legitimate peripheral participation. Legitimate peripheral participation describes a socialisation process of newcomers becoming experienced members in a community of practice. It is through legitimate peripheral participation that individual learning is connected to organisational learning (Brown & Duguid, 1991).

**Organisational Learning as social processes.**

Starting from the assumption that organisations are cultural entities (P. Cook & Yanow, 1993), organisations represent social communities whose social structures represent what the social entity knows and what it does (Kogut & Zander, 1992). Social structures represent the systems, rules and norms that through their application are constructed and reconstructed over time to become taken for granted by an organisation's members (Giddens, 1984).

Because social structures represent what an organisation knows, social structures create conditions and boundaries for learning among individuals and groups (Kogut & Zander, 1992, 1996). Thus, organisational learning can be understood as changes in social structures, which come about through the learning of an organisation's individual members. In this way Cook and Yanow (1993 p. 375) urged that a more useful way to understand organisational learning is as "concrete structural and procedural changes in the organization's patterns of activities".

Despite the usefulness of the 'Individual and organisational learning-as-cognition-and-social' school of thought there are limitations regarding learning processes that need to be considered. These relate to 1) an over-emphasis on social processes and 2) a focus on the communities that practitioners participate in.

Sfrard (1998) and Yakhlef (2010) cautioned that success of the 'Individual and organisational learning-as-cognition-and-social' school in drawing attention to the social processes of learning has led some scholars to down-play the role of cognitive processes. They argued a more balanced approach is required that recognises cognitive and social processes of learning in tandem.

The second limitation concerns a focus on communities where practitioners participate. The spread of social explanations of learning, and the communities of practice concept in particular, has concentrated scholars interest of different types of communities (Bogenrieder & Nooteboom, 2004; Lindkvist, 2005) and characteristics of communities themselves (Mittendorff, Geijsel, Hoeve, Laat, & Nieuwenhuis, 2006; Sawhney & Prandelli, 2000). However, some scholars argue a focus on communities has been at the expense of understanding the practices that occur within them and how practitioners come to learn through practicing (Handley, Sturdy, Fincham, & Clark, 2006; Roberts, 2006). This has led to a proposal for the concept of communities of practice to be reversed as practices of communities (Brown & Duguid, 2001; Contu & Willmott, 2006; Gherardi, et al., 1998; J. Swan, Scarbrough, & Robertson, 2002). Such a shift re-focuses scholarly endeavours on learning as situated and repeated actions among people in organisations.

To recap Section 2.1, the three schools of thought on organisational learning have generated substantial bodies of theory regarding organisational learning, which is summarised in Figure 2.1.

**Figure 2.1: Summary of key concepts on organisational learning from three schools of thought.**

| Dimensions | Main Points | Critique |
|---|---|---|
| 'Individual learning-as-cognition' school | | |
| Assumptions made regarding how learning occurs | Learning is an individual cognitive process | |
| Concepts used to explain learning processes | Acquisition of knowledge skills and attitudes (Dodgson, 1993)<br>Constructed meaning (N. M. Dixon, 1997) | Provides limited guidance on how organisations can learn beyond what individuals do (Popper & Lipshitz, 2000) |
| How learning across levels is explained | Assumes that learning across levels does not exist (H. A. Simon, 1991) | |
| How the role of context is considered | Organisational background influences individual learning (N. M. Dixon, 1997; Dodgson, 1993; H. A. Simon, 1991) | Ignores influence of organisational structures on individual action (Duncan & Weiss, 1979) |
| 'Individual and Organisational learning-as-cognition' school | | |
| Assumptions made regarding how learning occurs | Individual and organisational learning are cognitive processes | |
| Concepts used to explain learning processes | Theories of action (Argyris & Schon, 1978)<br>Routines (Levitt & March, 1988; Walsh & Ungson, 1991)<br>Process of knowledge acquisition, information distribution, interpretation and organisational memory (Huber, 1991)<br>Process of intuiting, interpreting, integrating, and institutionalising (Crossan, et al., 1999; Crossan, et al., 1995) | Anthropomorphism of organisations (P. Cook & Yanow, 1993)<br>Assumption of 'sharing' constructs (Kelley, 1955) |
| How learning across levels is explained | Individual and organisational learning processes are analogous | Use of hypothetical constructs (Popper & Lipshitz, 1998; Rouse & Morris, 1986) |
| How the role of context is considered | Organisational environment (Crossan, et al., 1999; Crossan, et al., 1995) | Underplays social aspects of learning (Blackler, 1995; Brown & Duguid, 1991; Nicolini & Meznar, 1995) |
| 'Individual and Organisational learning-as-cognition-and-social' school. | | |
| Assumptions made regarding how learning occurs | Learning is individual and organisational, cognitive and social | |

| | | |
|---|---|---|
| Concepts used to explain learning processes | Individual<br>Social learning theory (Bandura, 1986)<br>Legitimate peripheral participation (Brown & Duguid, 2001; Lave & Wenger, 1991)<br>Collective<br>Structural and cultural procedures (P. Cook & Yanow, 1993; Giddens, 1984; Kogut & Zander, 1992) | Down-plays the cognitive aspects<br>(Sfard, 1998; Yakhlef, 2010) |
| How learning across levels is explained | Through social structures<br>(P. Cook & Yanow, 1993; Giddens, 1984; Kogut & Zander, 1992) | |
| How the role of context is considered | Situated Activity (Lave & Wenger, 1991)<br>History and future (Bandura, 1986)<br>As communities (Brown & Duguid, 2001; Lave & Wenger, 1991) | Overemphasis on 'communities' as the context, at the expense of learning processes (Handley, et al., 2006; Roberts, 2006) |

Although different assumptions are made about how learning occurs, the role of individual, organisational and interorganisational levels, and how much focus is put on the role of context, the different schools of thought make important theoretical contributions. In particular, they explain why learning involves cognitive and social processes. However, a number of important research issues remain unresolved.

In the 'Individual and organisational learning-as-cognition and social' school most studies focus on learning within the boundaries of the firm. Given that some organisational activities are increasingly becoming interorganisational in nature, there are important questions about learning processes across firms and the role of context in those processes.

These important issues can be addressed with the practice-based view that I will review in section 2.3 following my survey of the organisational knowledge literature, which is next.

## 2.2 Conceptualising organisational knowledge

From the organisational learning perspective, knowledge is predominantly seen as the product of individual learning and an input for organisational learning (Duncan & Weiss, 1979; Huber, 1991). However, around the mid 1990s debates about the nature and processes of learning were picked up and continued under the explicit guise of organisational knowledge and knowledge management. These debates put knowledge as the central phenomenon of interest as opposed to being an assumed outcome of individual learning or an assumed input to organisational learning.

Interest in organisational knowledge as a strategic resource generated a new wave of research seeking to understand organisational performance through the management of knowledge processes both within and beyond organisational boundaries (Argote, McEvily, & Reagans, 2003; Easterby-Smith, Lyles, & Tsang, 2008). Scholars proposing the knowledge-based view argued that applied knowledge or 'know-how' that is embedded in organisational culture, rules and routines, and individual employees can provide long-term sustainable competitive advantage (Conner & Prahalad, 1996; R.M. Grant, 1996a; R. M. Grant, 1996b; Spender, 1996a, 1996b). This perspective focussed attention on acquisition of knowledge as the strategic resource of the firm.

Interest in knowledge acquisition grew particularly fast in regards to 'knowledge based' and 'high technology' industries. This was because in industries where an educated workforce and advanced knowledge and technology capabilities enable firms to adapt to rapidly changing environments (Crick & Spence, 2005), organisational knowledge is critical to firm survival (F. Murray, 2001).

Given the challenges of balancing the need to protect organisational knowledge with the need to develop new products through new knowledge combinations, Grant and Baden-Fuller (2004) proposed a knowledge access theory. Defining knowledge access as the application of knowledge from a partner's knowledge domain to the firm's products with an intention of maintaining the distinctive knowledge bases of both firms, they argued that through search, selection, coordination, integration and exploitation processes firms can sustain a knowledge-based competitive advantage.

The topic of organisational knowledge is informed by a range of disciplines integrating theories from accounting, economics, entrepreneurship, organisational behaviour, marketing, strategy and sociology (D. Teece, 1998). According to Foss, Husted, and Michailova (2010) various disciplinary contributions have led to some broad notions about knowledge that are agreed in the literature. Among these are 1) the definition of knowledge as " a mix of framed experience, values, contextual information and expert insight that provides a framework for evaluating and incorporating new experiences and information" (T. Davenport & Prusak, 1998), 2) characteristics and types of knowledge, and, 3) challenges of managing knowledge processes.

In describing knowledge Ryle (1949) distinguished between know-what and know-how. Know-what refers to 'facts' and declarative knowledge that can be expressed by the knower whereas know-how is characterised as procedural knowledge that is demonstrated through application. Similarly, Polanyi (1967) characterised knowledge according to explicit and tacit dimensions. Explicit knowledge refers to aspects that can be codified. This includes declarative knowledge that can be formalised or canonised in policies and procedures. In contrast, tacit knowledge refers to aspects that are embodied in experience. These include conceptual and sensory information, such as images, hunches and informed guesses, which come to be known through experience.

A number of scholars have integrated the 'know what-know how' and explicit-tacit characteristics to describe different types of knowledge. For instance Cowan et al (2005) distinguished between tacit knowledge as an individual's codes that enable him/her to know how to use a skill and codified knowledge as the documenting of those codes. From their perspective knowledge is an individual possession that resides either in individual codes (i.e.: mental model) or in documented form.

The notion of different types of knowledge also appears in other knowledge frameworks. For example, Collins (1993) proposed that knowledge can be categorised as embrained, embodied, encultured, embedded or encoded and that each knowledge type requires a different knowledge transfer mechanism. Other scholars have challenged this approach arguing that analytic typologies ignore that all knowledge is characterised by varying tacitness and explicitness. Furthermore, understanding that characteristics of knowledge require different management is more useful than categorising the different types (Johnson, Lundvall, & Lorenz, 2002).

Using Polanyi's explicit/tacit dimensions to characterise knowledge, Szulanski (1996) and Tyre and Von Hippel (1997) described tacit knowledge as 'sticky'. The term 'sticky' is used to describe the difficulties faced when transferring and managing knowledge within and across firms. In contrast knowledge is also described as 'leaky' (Liebeskind, 1996). This is because knowledge can spill over from one actor to be appropriated and used by another (D. Audretsch & Feldman, 1996b; Jaffe, Trajtenberg, & Henderson, 1993; Zucker & Darby, 1998). These contrasting descriptions of knowledge characteristics present different challenges for managing knowledge.

Stickiness and leakiness characteristics suggest that knowledge processes present communication and coordination challenges for firms (Kogut & Zander, 1996). Communication challenges relate to exchanging tacit knowledge that is difficult to transmit. Coordination challenges relate to difficulties of influencing what knowledge is available to others.

In regards to managing knowledge processes, a number of scholars identify the importance of know-how and tacit knowledge. Leonard-Barton (1995) argued firms' competitive advantage are based on various knowledge-building activities that produce and coordinate know-how. Knowledge-building activities include shared problem-solving,

implementing and integrating new tools and processes, and importing, and experimenting with and absorbing external technological and market knowledge. At the same time Davenport and Prusak (1998) argued that tacit knowledge is more difficult to manage because it is hard for firms to identify. Furthermore, when it can be identified, tacit knowledge is difficult to communicate and coordinate because it cannot be disconnected from the experience that produced it.

Coombes and Hull (1998) suggested the most appropriate method for understanding knowledge processes is to focus is on what happens in practice, rather than types of knowledge. Finding that knowledge practices vary across firms, Coombes and Hull (1998) argued management of knowledge practices can change innovation constraints, and thus, modify the path-dependence of a firm.

Argote, McEvily, and Reagans (2003) proposed different knowledge processes present different knowledge management challenges. Recognising multiple reasons for managing organisational knowledge, they distinguished three knowledge processes; knowledge creation as the generation of new knowledge in organisations; knowledge retention as embedding knowledge in organisations; and, knowledge transfer as acquiring knowledge from another unit or organisation. Argote et al (2003) argued social relations among actors and contextual features are likely to have different influences on the different knowledge processes.

With regards to knowledge transfer processes van Wijk, Jansen, and Lyles (2008) noted that scholars have used a number of similar terms to label related knowledge processes. These include knowledge sharing (M. Hansen, 1999), knowledge transfer, knowledge flows (Gupta & Govindarajan, 2000), and knowledge acquisition (Darr, Argote, & Apple, 1995). Similarity between terms is illustrated in these common definitions of knowledge transfer and knowledge sharing:

> "Organizational knowledge transfer refers to the process through which organizational actors – teams, units, or organizations – exchange, receive and are influenced by the experience and knowledge of others" (van Wijk, et al., 2008 p. 832).

> "Knowledge sharing as activities of transferring or disseminating knowledge from one person, group or organization to another" (Lee, 2001 p. 324)

Given similarity in these definitions, it is useful to use one of them for consistency. Given this, the thesis uses the term 'knowledge sharing' but recognises the other terms and draws on studies using them.

Two perspectives on organisational knowledge can be identified in sorting through the various contributions. Cook and Brown (1999) labelled the perspectives as 'epistemology of possession' and 'epistemology of practice'; Swan et al (1999) used cognitive and community models as labels; Gherardi (2001) referred to mental and functional perspectives and Marshall (2008) referred to cognitive and social-based theories. Possessive/cognitive/ mental perspectives (herein referred to as the possessive view) tend to focus on individual knowledge, rather than collective knowledge, and explicit knowledge rather than tacit knowledge. In contrast, practical/community/functional/social perspectives (herein referred to as the practical view) tend to focus on collective knowledge and tacit knowledge as it is used in action.

Irrespective of labelling the two perspectives have generated substantial bodies of theory regarding organisational knowledge (Marshall, 2008). However, across the perspectives scholars make different assumptions about the relationship between organisational learning and organisational knowledge. Given the different assumptions it might be difficult to integrate various contributions into a single and coherent theory of organisational knowledge (Chiva & Alegre, 2005).

In addition to concerns about reconciling different perspectives into a single and coherent theory, there are also issues regarding the development of comprehensive explanations of knowledge sharing. Scholars from the two perspectives have proposed important knowledge sharing concepts. Some focus on knowledge sharing mechanisms that involve transmission of codified or explicit knowledge. In contrast, others concentrate on socialisation mechanisms that focus on sharing tacit knowledge. However, cross-fertilisation of the perspectives has been limited, which potentially limits our understanding about knowledge sharing and organisational knowledge (Marshall, 2008).

Knowledge sharing concepts raise the matter of context and its role. Some scholars identify context as a variable that is external to knowledge sharing, which can be controlled for (Augier, Shariq, & Vendelø, 2001), whereas other scholars identify context as an aspect

that is central to understanding knowledge (Brown & Duguid, 2001). Given these differing viewpoints outlined above, it is useful to review the different perspectives on organisational knowledge along three dimensions:

1. Assumptions about the relationship between organisational learning and organisational knowledge;
2. Concepts used to explain how knowledge is shared; and,
3. Consideration of the role of context in relation to knowledge sharing

### 2.2.1 Possessive view

This section reviews the possessive view of organisational knowledge. These scholars develop their explanations of the learning-knowledge relationship based on arguments about absorptive capacity. Concentrating on external learning Cohen and Levinthal (1989, 1990) proposed a theory of absorptive capacity to explain firms' ability to acquire and assimilate knowledge through external learning. According to their absorptive capacity argument prior knowledge and investments in R&D influence firms' future ability to learn. Using cross-sectional survey data about learning opportunities collected from R&D lab managers in the American manufacturing sector, Cohen and Levinthal (1989, 1990) showed that learning is greatest when new knowledge can be assimilated into existing knowledge structures. This is because organisational learning is a cumulative path-dependent process that is influenced by firms' prior basic knowledge and willingness to invest in new learning. Basic knowledge refers to a general understanding of the discipline traditions and techniques that firms operate in. Relevancy of basic organisational knowledge for future organisational learning is important because it enables firms to understand the assumptions that new knowledge is based upon making it easier to assimilate and use. In summary, absorptive capacity explains organisational knowledge as the result of firms' investments in external learning.

Lane and Lubatkin (1998) extended Cohen and Levinthal's (1990) theory arguing characteristics of the learner firm and teacher firm present a third factor influencing firms' ability to use external learning for firms' organisational knowledge. Reconceptualising absorptive capacity as a dyadic construct Lane and Lubatkin (1998) proposed the ability of

one firm (the learner firm) to learn from another (the teacher firm) depends upon similarity of knowledge bases. Testing their hypotheses on pharmaceutical-biotechnology alliances data, they provided important insights into the relationship between organisational knowledge and external learning. Similarity between organisational knowledge bases is important because it provides cognitive proximity that learner firms need in order to recognise the value of new external knowledge provided by teacher firms. If learner firms do not possess some prior common knowledge, it is very difficult for them to value and internalize teacher firms' expert knowledge for their own operations.

Finkelstein and Haleblian's (2002) examination of organisational acquisitions supported Lane and Lubatkin's (1998) relative absorptive capacity theory. Testing the hypothesis that future acquisition performance is influenced by prior acquisition experience, their study found performance of a firm's second acquisition depends upon the ability to transfer routines and practices established in the first acquisition to new situations. They argued ability to transfer routines depends upon similarity of industrial environment, suggesting that similarity in industrial environment is an important contextual factor influencing knowledge transfer processes.

DeClerq and Dimov (2008) argued a firm's knowledge access strategy is important for organisational performance, especially when it lacks absorptive capacity to access knowledge outside its knowledge domain and that knowledge is critical to future product development. Testing their hypothesis that internal knowledge development and external knowledge access strategies have different performance effects on data from the venture capital industry, DeClerq and Dimov (2008) found interactions among competing organisations can create a context where internal experience and learning improvements do not translate into competitive advantage. Based on the findings, these scholars argued firms who lack knowledge for a particular task are more likely to perform better if they access external knowledge through relationships compared to attempting to acquire that expertise.

Other scholars take a different approach to the learning-knowledge relationship. Specifically they view individual learning as an input to organisational knowledge. One of the most influential theories of organisational knowledge is Nonaka's (1994) knowledge creation theory, which starts from the assumption that the most valuable knowledge in an organisation is know-how. According to Nonaka's (1994) theory learning is an individual

process that creates individual knowledge which can be shared with individuals and groups to create organisational knowledge. From this perspective facilitating the sharing of tacit and explicit aspects of individuals' learning is an important aspect of managing organisational knowledge (Nonaka & Teece, 2001).

In his knowledge creation theory Nonaka (1994) addressed knowledge sharing as part of the broader knowledge creation process of socialisation, externalisation, combination and internalisation. Socialisation involves individuals sharing their tacit knowledge through face-to-face experiences; externalisation involves developing concepts that enable tacit knowledge to be made explicit; combination involves integrating different explicit knowledge to create new knowledge for the firm. Internalisation involves individuals integrating the firm's new knowledge to develop their personal knowledge. In explaining these mechanisms Nonaka stressed they are based on organisational context, which makes it difficult to share knowledge with other organisations.

Schmickl and Kieser (2008) made similar assumptions to that individual learning is an input to organisational knowledge. In contrast, they claimed that knowledge sharing should be focussed on integrating organisational knowledge rather than promoting cross-learning by individuals. They argued given the limitations to individual learning, it is more efficient to coordinate knowledge sharing for knowledge integration, that is

> "coordinating in a way that the solutions specialists in one field come up with are compatible with the solutions contributed by specialists from other fields"(Schmickl & Kieser, 2008 p. 473).

From prior studies of incremental product innovation Schmickl and Kieser (2008) identified transactive memory, modularisation, and prototyping as structural mechanisms shown to reduce knowledge sharing costs by integrating knowledge. Transactive memory is "directories held by members of a group or an organization that help to identify the existence and location of knowledge held by other individuals" (Schmickl & Kieser, 2008 p. 477). Modularization refers to breaking down of products or processes into simpler components for independent development by specialists followed by re-composition of completed components into a functioning whole. Prototyping refers to an iterative trial and error process of aligning the components that different specialists develop.

Testing these mechanisms in the context of knowledge sharing between specialists involved in radical product innovation at an electrotechnical company, Schmickl and Kieser (2008) found evidence these mechanisms support knowledge integration when specific requirements can be made. However, when requirements are not known or are unclear, these structural mechanisms are insufficient and specialists rely upon socialisation mechanisms. This suggests task characteristics are an important contextual aspect that influences knowledge sharing.

Assuming codified and personal knowledge (individual knowledge) are inputs for team learning, Haas and Hansen (2005) theorised that nature of the task and experience of the learning team are likely to influence search and transfer costs of knowledge sharing. Testing their hypotheses on data from a professional services firm, they found codified knowledge becomes less useful for team learning as tasks became more differentiated, providing further evidence that nature of the task is an important contextual factor. They also found positive support that experience of the learner is an important contextual factor regarding search and transfer costs for knowledge sharing. Specifically they found codified and personal knowledge was less useful for experienced teams' learning compared to inexperienced teams.

Some of the strongest evidence about the importance of the nature of the task is provided by van Wijk et al (2008). Their meta-analysis on knowledge transfer confirms the ambiguous nature of knowledge makes sharing a difficult process. Furthermore, van Wijk et al's (2008) results indicated that knowledge ambiguity is more detrimental to interorganisational knowledge sharing processes than intraorganisational ones. On other hand, they found that knowledge exchange is less influenced by ambiguity compared to knowledge acquisition. Van Wijk et al (2008) noted these findings raise some interesting questions for future research regarding the fine distinctions between knowledge sharing processes for knowledge acquisition and knowledge access. Furthermore, they suggested that understanding these fine distinctions calls for a qualitative approach to appreciate them.

As well as knowledge task characteristics, role of the individual is another important contextual factor influencing knowledge sharing. Examining organisational learning in a biomedical consortium Andrews and Delahaye (2000) argued individuals' knowledge sharing processes are mediated by a psycho-social filter. They identified three individual

level factors - approachability, credibility and trustworthiness – that act as a psychosocial filter influencing individuals' decisions to share individual knowledge for organisational learning.

Husted and Michailova (2002) took a slightly different position towards knowledge sharing. They argued individuals' unwillingness to share knowledge, often discussed in the literature as 'Not Invented Here' or NIH syndrome, is a natural state. Furthermore, they argued organisational knowledge sharing environments could vary from mildly hostile to extremely hostile, which require different management tactics. Given this, Husted and Michailova (2002) claimed that knowledge sharing can be understood as a systematic process that focuses on benefits for the organisation, rather than benefits for individuals in the organisation.

To focus on benefits to the organisation Husted and Michailova (2002) argued that managers should focus on connecting individuals so the knowledge of some individuals can be an input to the learning of others. In addition to understanding levels of hostility in the knowledge-sharing environment, managers need to consider the characteristics of the knowledge transmitter, the knowledge receiver and the knowledge itself as these are likely to influence what knowledge sharing mechanisms should be used.

Litchenthaler and Ernst (2006) argued in the context of external knowledge processes individuals' attitudes towards knowledge sharing can be understood in a number of ways. Their framework identifies six possible syndromes - NIH, 'buy-in' in knowledge acquisition, 'all-stored-here', 'relate-out' in knowledge accumulation, 'only-used-here' and 'sell-out'. They claimed that as external knowledge becomes an increasingly important part of firms' competitive advantage it is important to understand these various individual attitudes and recognise different methods for managing them.

A different perspective can be found in economic geography where scholars argued knowledge is shared through spillovers. In this line of research knowledge is assumed to be the result of firms' absorptive capacity. Furthermore, as it spills beyond the boundaries of the firm knowledge can be appropriated by other firms. According to this argument knowledge spillovers are an important knowledge sharing mechanism because they provide firms with access to new economic knowledge (D. Audretsch & Feldman, 2004).

Studies of knowledge spillovers also highlighted the importance of geographic context for understanding knowledge sharing. Acknowledging it is difficult to study how knowledge moves from one actor to another retrospectively, especially when it is tacit know-how, these scholars argued that patents provide a codified representation of knowledge that leaves a "paper trail" for investigation (D. Audretsch & Feldman, 1996b; Jaffe, et al., 1993; Rosenkopf & Almeida, 2003). Using patent citation as a proxy for knowledge spillovers, these studies provide evidence that knowledge spillovers are geographically localised.

Network oriented studies also emphasised the role of knowledge sharing for organisational learning. According to Nahapiet and Ghoshal (1998) structural, relational and cognitive dimensions of social relations influence what organisational knowledge resources can be accessed. The structural dimension involves configurations of relations and can influence access to and the amount of organisational knowledge sharing (Reagans & McEvily, 2003). The relational dimension, which refers to the nature of the relationships, can increase the frequency of interactions leading to greater knowledge sharing (Reagans & McEvily, 2003). The cognitive dimension consists of shared representations, interpretations, and, systems of meaning that can promote mutual understanding, which helps actors share their knowledge (Inkpen & Tsang, 2005).

Taking the network perspective to examine intraorganisational knowledge sharing for innovation Hansen (1999) examined influences of network tie-type and knowledge characteristics on knowledge sharing. Using a social network analysis of 120 new product development projects across 41 divisions of a large electronics company, Hansen (1999) found weak ties are effective for searching out knowledge compared to strong ties. Conversely, strong ties are more effective for transferring complex knowledge compared to weak ties.

The network perspective was also used by Bell and Zaheer (2007) who argued networks provide knowledge sharing mechanisms that operate across organisational boundaries and geographic spaces. Their quantitative analysis of 77 Canadian mutual fund companies found the effect of different network ties varies across geographic spaces. Specifically, institutional-level ties are valuable for geographically proximate knowledge sharing only, whereas organisation-level ties are poor knowledge sharing mechanisms irrespective of geographic

location. In contrast, individual-level friendship ties are superior knowledge sharing mechanisms in geographic proximate and geographic distance spaces.

Owen-Smith and Powell's (2004) study emphasised the role of interorganisational ties and geography for knowledge sharing also. In their study of human therapeutics firms in the Boston area over a 10-year period, Owen-Smith and Powell (2004) distinguished between channel and conduit knowledge sharing mechanisms. Channels refer to individual and organisational ties that facilitate knowledge spillovers among loosely connected participants, whereas conduits refer to individual and organisational ties that facilitate specific exchanges among participants who are connected through contractual linkages. Their social network analysis of strategic alliance and patent citation data found channels are more informal knowledge sharing mechanisms are less salient in geographically dispersed and institutionally diverse networks. In contrast, pipelines are predominant and more formal knowledge sharing mechanisms used in geographically dispersed networks. These findings affirmed contributions from economic geography that geographical location is an important contextual aspect that influences knowledge sharing.

The role of informal knowledge sharing mechanisms was also the focus of Murray's (2002) study on co-evolution of knowledge in tissue engineering. Recognising that during commercialisation knowledge from the science field and technological field co-evolves, Murray (2002) identified informal knowledge sharing mechanisms that facilitate knowledge sharing across science and technology fields. Using patent citations as a proxy for knowledge in the technology field and academic paper citations as a proxy for knowledge in the science field, she employed a patent-paper citation pairing method to identify knowledge sharing patterns across the fields. Exploring patent-paper citation patterns through in-depth interviews, Murray (2002) identified joint authorship, movement of students and post-doctoral fellows, and positions on scientific advisory boards as important informal knowledge sharing mechanisms operating at the individual-level.

### 2.2.2 Practical view

Where scholars taking the possessive view assume individual learning leads to organisational knowledge and, that organisational knowledge is an input to organisational

learning, scholars of the practical view take a different approach. They argue it is difficult to distinguish learning and knowing as purely individual activities. (S. Cook & Brown, 1999). More specifically the practical view assumes learning and knowledge are social endeavours:

> "Knowledge is not what resides in a person's head or in books or in data banks; to know is to be capable of participating with requisite competence in the complex web of relationships among people and activities" (Gherardi, et al., 1998 p. 274).

Knowledge refers to practical actions taken by collections by people, such as groups and firms, in order to socially construct agreed meanings among themselves in relation to those actions (Gherardi, 2009d). Thus, to draw attention to a view of knowledge is an active process rather than an object, the verb 'knowing ' is used (Suchman, 1987).

Blackler (1995) remarked the tendency by some scholars to compartmentalise knowledge as static objects provides little insight into how people become knowledgeable. Taking a social constructive perspective Blackler (1995) argued that situated, mediated, provisional and pragmatic aspects need to be appreciated to understand how people become knowledgeable and able to share their knowing. Situated aspects are important to understanding how knowing is located in time and space. Mediated aspects are important to understanding social systems, language, technologies and objects are involved in the construction of knowledge. Provisional aspects are important due to constant (re)construction of knowledge that makes it dynamic. Pragmatic aspects are important to understanding different purposes for knowing. Blackler (1995) claimed consideration of these aspects is necessary to understanding knowing and knowledge sharing as active and ongoing processes.

In his examination of interactions among medical professionals making telemedicine diagnoses Nicolini (2007) discussed the situated and pragmatic nature of knowing across disciplinary and geographic boundaries. The study showed changes in medical practices were made possible through temporal and spatial re-distribution of work arrangements, highlighting the situated aspect of context. Re-distribution involved constructing new understandings about the nature and content of activities involved in assessing patient conditions and determining the course of healthcare treatment. This was necessary so medical professionals working with patients and medical professionals consulting by

distance understood their roles in the telemedicine situation. Constructing new understandings often involved reconstructing existing understandings about how professionals would be held accountable for these changing activities. Nicolini (2007) concluded construction of meaning is important to understanding how workers operating in different disciplinary fields share knowledge through processes of negotiation.

Tyre and von Hippel's (1997) study of responses to technical problems with new process machinery pointed to the situated and mediated nature of adaptive learning. Exploring the introduction of the same new production machines into two unrelated factory contexts, they found each organisational setting required different processes for problem-solving. This was due to differences in clues provided about underlying issues, resources available for generating and analysing information and assumptions made on the part of problem solvers.

Orr's (1996) ethnography of copier repair technicians at Xerox illustrated the mediated and pragmatic aspects of practices used by photocopiers technicians. His field observations described elaborate and complex informal work practices developed by communities of technicians to 'work around' prescriptive support documentation that was not helpful to them solving 'on-the-spot' problems. Actions of the technicians demonstrate the pragmatic nature of practices in that they are often modified to be 'good enough' for the situation at hand (Brown & Duguid, 1991).

To overcome barriers in cross-disciplinary work Brown and Duguid (1998) claimed enabling architectures are required. They describe enabling architectures as structural mechanisms and roles that facilitate learning and knowledge. These roles include organisational translators who are "sufficiently knowledgeable about the work of both communities to be able to translate" (p. 103) and knowledge brokers who participate in different disciplinary worlds and translate across them.

Bechky's (2003) ethnography of misunderstandings at work suggested why co-creation of common ground is necessary to overcoming complex problems. Examining interactions between engineers, technicians, and assemblers on a production floor, she found misunderstandings were underpinned by differences in language, locus of practice, and conceptualization of the product. By recognising these social aspects Bechky (2003) concluded that understanding the situatedness of local work contexts is crucial to

understanding why problem-solving and knowledge sharing across occupational groups is provisional to the context where knowing is constructed.

Similarly Tagliaventi & Mattarelli's (2006) ethnography of knowledge sharing across professional groups in a hospital unit demonstrated the importance of behaviours that support the negotiation of occupational values as new work practices are introduced. Using a grounded theory method their study draws attention to provisional nature of knowledge. Analysing the negotiation of acceptable practices among individuals from different professional groups, their study highlights the importance of boundary spanning and working side-by-side behaviours in the re-construction of knowing.

Nag et al's (2007) case study of an attempted strategic transformation found organisational identity and existing practices were major barriers to a R&D-oriented organisation learning to become a market-oriented organisation. In their study the firm being examined attempted to 'graft' non-technological knowledge to its engineering-focussed business as a way of becoming market-oriented. These efforts were undermined by competing notions of what was conceived as knowledge, thus drawing attention to its provisional nature knowledge.

What these scholars highlight is the difficulty of sharing expertise, experience and insights across disciplinary and organisational fields. While a number of knowledge sharing concepts have been proposed to explain the relationship between learning and knowledge, including enabling architecture (Brown & Duguid, 1998), new meaning construction (Nicolini, 2007), clues (Tyre & von Hippel, 1997), grafting (Nag, et al., 2007), boundary spanning and working side-by-side (Tagliaventi & Mattarelli, 2006), there are also criticisms of the practical view in regards to how it informs the management of knowledge processes.

Foss et al (2010) argued that sociological explanations of learning and knowledge are not forthcoming on how management can influence positions and relations to govern knowledge sharing. They argued that it is necessary to look below the level of the collective (groups and firms) to understand the micro-foundations of individual behaviour. Foss et al's (2010) critique of the practical view of organisational knowledge is similar to Sfrard's (1998) and Yakhlef's (2010) concerns about the 'Individual and organisational learning-as-cognition-and-social' school, which were outlined in Section 2.1.3. More specifically in

drawing attention to social processes, some scholars have downplayed the role of cognitive processes.

To recap Section 2.2, knowledge sharing is an ongoing concern in the organisational knowledge literature. Its importance is reflected in the number of concepts reviewed from the possessive and practical view, which are summarised in Figure 2.2. Yet, to advance ongoing inquiry into knowledge processes what is needed is a more balanced approach that recognises cognitive and social processes of learning and knowing in tandem (Marshall, 2008; Sfard, 1998; Yakhlef, 2010). In the next section, I introduce the practice-based view as such an approach and outline reasons for its appropriateness.

**Figure 2.2: Summary of key concepts on organisational knowledge from possessive and practical views.**

| Dimensions | Main Points | Authors |
|---|---|---|
| Possessive view | | |
| Relationship between organisational learning and organisational knowledge | Individual learning influences organisational knowledge<br>Organisational knowledge influences organisational learning | (Andrews & Delahaye, 2000; Cowan, et al., 2005; Haas & Hansen, 2005; Nonaka, 1994; Schmickl & Kieser, 2008)<br>(D. Audretsch & Feldman, 1996b; Bell & Zaheer, 2007; Cohen & Levinthal, 1989, 1990; De Clercq & Dimov, 2008; Jaffe, et al., 1993; Lane & Lubatkin, 1998; Rosenkopf & Almeida, 2003; Zahra & George, 2002) |
| Concepts used to explain how knowledge is shared | Socialisation, Externalisation, Combination and Internalisation<br>Knowledge spillovers<br><br>Social Capital / Network ties<br><br>Search and transfer costs<br>Formal mechanisms<br>Conduits/Pipelines<br>Transactive memory, modularisation, prototyping<br>Informal mechanisms<br>Channels, joint authorship, movement of students and post-doctoral fellows, positions on scientific advisory boards | (Nonaka, 1994)<br><br>(D. Audretsch & Feldman, 1996b; Jaffe, et al., 1993; Rosenkopf & Almeida, 2003)<br>(Bell & Zaheer, 2007; M. Hansen, 1999; Nahapiet & Ghoshal, 1998; Owen-Smith & Powell, 2004; Reagans & McEvily, 2003)<br><br>(Haas & Hansen, 2005; Schmickl & Kieser, 2008)<br><br>(Owen-Smith & Powell, 2004)<br>(Schmickl & Kieser, 2008)<br><br>(Fiona Murray, 2002; Owen-Smith & Powell, 2004) |
| Role of context in relation to knowledge sharing | Geography<br><br>Discipline Field / Institutional or Industrial environment<br>Organisational characteristics<br>Absorptive capacity<br>Experience of the learner<br>History, culture<br>Knowledge characteristics | (D. Audretsch & Feldman, 1996b; Bell & Zaheer, 2007; Jaffe, et al., 1993; Rosenkopf & Almeida, 2003)<br>(Finkelstein & Haleblian, 2002; Lane & Lubatkin, 1998; Nahapiet & Ghoshal, 1998)<br><br>(Cohen & Levinthal, 1990; Zahra & George, 2002)<br>(Haas & Hansen, 2005)<br>(Nonaka, 1994; Nonaka & Teece, 2001) |

| | | |
|---|---|---|
| | Nature of the task<br>Knowledge ambiguity<br>Individual characteristics<br><br>Psycho-social filter<br>Receiver and transmitter attitudes | (Haas & Hansen, 2005; Schmickl & Kieser, 2008)<br>(M. Hansen, 1999; Husted & Michailova, 2002; van Wijk, et al., 2008)<br><br>(Andrews & Delahaye, 2000)<br>(Husted & Michailova, 2002; Lichtenthaler & Ernst, 2006) |
| Practical view | | |
| Relationship between organisational learning and organisational knowledge | Learning and knowing are interwoven | |
| Concepts used to explain how knowledge is shared | Enabling architecture<br>New meaning construction<br>Clues<br>Grafting<br>Boundary spanning<br>Working side-by-side | (Brown & Duguid, 1998)<br>(Nicolini, 2007; Orr, 1996; Tagliaventi & Mattarelli, 2006)<br>(Tyre & von Hippel, 1997)<br>(Nag, et al., 2007)<br>(Tagliaventi & Mattarelli, 2006)<br>(Tagliaventi & Mattarelli, 2006) |
| Role of context in relation to knowledge sharing | Situated, mediated provisional and pragmatic aspects<br>Boundaries of disciplinary fields<br>Boundaries of organisational fields | (Blackler, 1995)<br>(Carlile, 2002; Nicolini, 2007; Tagliaventi & Mattarelli, 2006)<br>(Bechky, 2003; Nag, et al., 2007; Orr, 1996; Tyre & von Hippel, 1997) |

## 2.3 Practice-based view of learning and knowing

The practice-based view of learning and knowing is an analytical approach that recognises everyday practices as central to understanding the social construction of learning and knowing. The practice-based view draws concepts from different theories of practice to provide a heuristic for seeing and analysing learning and knowing as social phenomena (Reckwitz, 2002).

To understand the practice-based view it is useful to distinguish between *practice* and *practices*. Reckwitz (2002) distinguished practice in the singular to describe praxis and the whole of human action and practices in the plural to describe routinised types of behaviour. Thus theories of practice refer to "any theory that treats practices as a fundamental category, or take practices as its point of departure" (Stern, 2003 p.185). In this way the 'practice' approach can, according to Schatzki (2001 p. 2), be demarcated as

> "all analyses that (1) develop an account of practices, either the field of practices or some sub-domain thereof (e.g.: science), or (2) treat the field of practices as the place to study the nature and transformation of their subject matter".

Three concepts are central to understanding the practice-based view, and are reviewed in the following sections. First, there is the nature of practices and the elements that make them up. Second, there are sites where practices are performed. Given the various ways that sites of practices have been conceptualised, it is useful to review how different concepts account for physical, temporal and teleological aspects (T. Schatzki, 2002). Third, is the notion of membership and different roles that provide access to sites.

### 2.3.1 Practices

According to Corradi, Gherardi, and Verzelloni (2010) use of the term 'practices' falls into three broad categories. Practice is used to refer to learning methods that involve repetition. Practice is also used to refer to an occupation, such as 'medical practice' or 'legal practice'.

The third way that the term practice is used is to refer to how something is done. It is the third category that is used by practice theorists.

Schatzki (2001 p. 2) defined practices as "embodied, materially mediated arrays of human activity centrally organized around shared practical understanding". 'Embodied aspects' of human activity and 'practical understanding' reflect the assumption that learning and knowing are practical accomplishments that reside in the application of skills and know-how. 'Materially mediated' aspects recognise how performance of skills is influenced by social systems, language, technologies and objects that individuals use.

Human activity that makes up a practice is described by Schatzki (2002 p. 71) as "a set of doings and sayings". 'Doings' refer to things that people directly do with their bodies, such as waving, standing and touching; 'sayings' refer to communicating about something, such as through language. Performance of 'doings and sayings' can involve a number of interconnected elements. These elements include un-reflexive reactions, actions, utterances, linguistic acts, behaviours, routines and objects that acquire meaning when in use. So while practices are made up of those elements, practices are not reducible to any one of them (T. Schatzki, 1996).

The nature of practices as made up of 'doings and sayings' is captured in Warde's (2005) definition of practices as "coordinated entities [which] require performance for their existence". By specifying a performative element, Warde (2005) acknowledged 'doings and sayings' are recognised as practices through the performance of them. In this way it is practicing that "actualizes and sustains practices" (T. Schatzki, 1996 p. 90). Schatzki (2002) uses the example of waving a hand to illustrate this point as the performance of waving a hand distinguishes it as a greeting as opposed to calling someone over.

Warde's (2005) definition also recognised how 'doings and sayings' make up a practice involving some coordinated action regarding how elements hang together to represent a shared practice. Schatzki (1996) proposed the nexus of 'doings and sayings' that produce practices can be coordinated through three mechanisms. First, there are understandings of what to do and say. Second, there are procedures including rules, principles, precepts and instructions. Third, there are objectives or teleology whose interpretation regarding purpose and means can be discerned by those taking part in a practice.

The teleology of practices highlights how context in which 'doings and sayings' are performed influences their meaning. Using his hand-waving example Schatzki (2002) made the point that waving a hand in one context constitutes a greeting but in another context it represents calling someone over. For this reason, the set of actions that encompasses a practice is always broader that its 'doings and sayings'; it also includes the sites or context in which the 'doings and sayings' are performed. Given this, it is necessary to consider sites as part of the practice-based view.

### 2.3.2 Sites of practices

Concerned with context, scholars have used a number of concepts to describe sites of practices. Sites of practices refer to "a context, some or all of whose inhabitants are inherently part of it" (T. Schatzki, 2002 p. 146). These site concepts include fields of practice (T. Schatzki, 2002; Schaztki, 2001), cultural fields (Bourdieu, 2005), communities of practice (Lave & Wenger, 1991), networks of practice (Brown & Duguid, 2001), and social worlds (D. Unruh, 1979; 1980).

For Schatzki (2003), sites of practice are more than physical locations where practices take place. They have a temporal (or timing) aspect that gives meaning to actions depending upon when the practices are performed. Sites of practice also have a teleological aspect that give meaning to practices depending upon the means and ends that are sought. Thus, when reviewing different concepts used to describe sites of practice it is useful to consider how they consider physical, temporal and teleological aspects.

#### 2.3.2.1 Fields of practice

Schatzki (2001 p. 2) defined *fields of practice* as

> "the total nexus of interconnected human practice" where phenomena such as knowledge, science and social institutions can be investigated. From this perspective fields of practice are social sites where human activities and material arrangements mesh together and give meaning to those activities and arrangements".

As outlined above, Schatzki (2003) conceived fields of practice as being made up of physical, temporal and teleological aspects. Physical aspects are important to understanding how practices in different fields interweave when they are not in spatial proximity to one another. Temporal aspects are important so that actors who carry out practices do so in ways that are meaningful to other actors who will sustain them in the future. Teleological aspects are important to understanding why arrangements can reach across fields independent of the practices found in either field. This explains why similar means can sometimes achieve different ends and vice versa.

### 2.3.2.2 Cultural fields

Bourdieu (2005) used the notion *cultural fields* to describe sites where practices take place. Cultural fields refer to

> "a domain of activity marked by particular objective conditions, certain overall goods to be pursued (stakes), a range of capitals that are drawn on when pursuing them, the layouts of the settings where the field's activities transpire, and a space of actual and possible activities and meanings"(T. R. Schatzki, 2003 p. 191).

Bourdieu and Wacquant (1992) claimed that understandings imbued in practices depend upon the cultural fields where practices are carried out. This is because *habitus* or taken-for-granted ways of perceiving, interpreting, expressing and acting, influence how practices are performed.

Bourdieu (1990) argued individuals' early experiences are crucial to forming habitus and thus determining future practices. Given this, actors' are likely to respond to new situations by assimilating them in to their habitus. In this way habitus not only informs the dispositions that individuals bring into situations, but it also influences their ability to deal with change (Mutch, 2003). Mutch's (2003) study of UK bar managers illustrated how habitus of bar managers were embodied in their interactions with staff and customers. However, as ownership arrangements changed from small owner-operated establishments towards chains owned by multi-national corporations, managers' habitus made it difficult for them to change their practices in accordance with new owners' expectations.

Importance of early experiences implies a role for physical sites in the formation of habitus. However, once habitus has formed Bourdieu had little to say about the role of physical aspects of cultural fields. On the other hand he argued that temporal aspects are crucial to understanding cultural fields because agents' cultural fields are both the historical result of habitus and an influence of future practices (Bourdieu, 2005). Similarly Bourdieu (1988) recognised teleological aspects of cultural fields arguing that goals and means of practices are deeply embedded in habitus.

### 2.3.2.3 Communities of practice

Lave and Wenger (1991 p. 98) introduced the concept of *communities of practice* to describe "an activity system about which participants share understandings concerning what they are doing and what that means for their lives and for their communities". According to Wenger (2003) communities of practice are characterised by shared ways of doing things together, mutually defined identities and a shared discourse reflecting a certain perspective on the world. It is also these characteristics of communities of practice where differences and dependencies in practices can lead to the formation of new knowledge (Osterlund & Carlile, 2005).

Brown and Duguid (1991) claimed communities of practice are sites where learning, working and innovation occur through improvisation of existing practices and creation of new ones. Their argument was premised on there being differences between formal descriptions of work, which they referred to as canonical practices, and actual practices that employees perform, which they termed non-canonical practices. They argued canonical practices create barriers to people doing their jobs because canonical practices cannot capture the realities of actual work. This leads employees to take on more non-canonical practices in an attempt to improvise. Using Orr's (1996) ethnography of copier repair technicians at Xerox, Brown and Duguid (1991) illustrated how elaborate and complex non-canonical practices developed by communities of technicians to 'work around' the prescriptive support documentation provided by the firm.

Communities of practice has been used as an analytic lens for understanding communities within firms, often by re-casting groups or teams as communities (for example

Hildreth & Kimble, 2004; Mittendorff, et al., 2006; Mutch, 2003; Sole & Edmondson, 2002). Other scholars have viewed firms as communities (for example, Andriessen & Fahlbruch, 2004; Andriessen, Soekijad, & Keasberry, 2002; Saint-Onge & Wallace, 2003; Wenger, et al., 2002). Yet despite the popularity of the communities of practice concept, a number of problems exist in using it to understand sites of practices.

In his earlier work Wenger (1998 p. 131) conceptualised communities of practice as spatially constrained to "the local character of mutual engagement". In his later work he revised this view recognising the success of communities of practice "depend on their ability to design themselves as social learning systems and also to participate in broader learning systems such as an industry, a region or a consortium" (Wenger, 2003 p. 76). This physical aspect remains under-theorised leading Benner (2003) to call for more theory-building and empirical studies that explore communities of practices as components of spatially distributed economic learning processes.

On the question of how communities of practices can be understood as part of larger social sites, Coe and Bunnell (2003) theorised that communities who originate in a local context might create new spatially extensive communities and constellations through boundary spanning processes. A number of other scholars suggested that relational proximity, which is closeness of relations in terms of norms, values and rules of thought and action, can explain why sites of practices are not spatially bound (Amin & Cohendet, 2004; Amin & Roberts, 2008; Coenen, et al., 2004; Lechner & Dowling, 2003). However, these conceptual arguments require theoretical development and empirical exploration.

A further limitation relates to teleological aspects. Scholars assume that communities of practice exist because members have similar reasons for participating in them (Wenger, et al., 2002). However, due to different means used to produce them and different ends they can seek to achieve, practices have a teleological aspect. The teleological aspect is mainly ignored in communities of practice suggesting a further shortcoming in its use for understanding sites of practices (Cox, 2005).

#### 2.3.2.4 Networks of practice

In regards to spatial aspects, networks of practice are presented as an alternate way of describing sites of practices. Brown and Duguid (2001 p. 412) defined networks of practice as "cross-firm networks of practice are built by people who share similar work practices, discourses, and knowledge, frequently centred in a common occupation or profession". In contrast to communities of practice, networks of practice conceptualise the performance of practices as spatially distant activities. Acknowledging their importance for information sharing, Brown and Duguid (2001) argued that networks of practice are not a basis for action or knowledge development, which they claim can only take place within communities of practice.

A number of scholars use networks of practice to explore various aspects of learning and innovation (Ormrod, Ferlie, Warren, & Norton, 2007; Tagliaventi & Mattarelli, 2006; van Baalen, Bloemhof-Ruwaard, & van Heck, 2005; Wasko & Faraj, 2005). Yet, none of them explicitly explored how physical aspects influence practice suggesting further research is needed to explain how and why geography influences practices. Furthermore, how and why geographically distant practices become collectively understood and lead to change in firms' activities requires closer attention to temporal and teleological aspects as well as physical ones.

### 2.3.3 Membership

A number of terms have been used to describe membership roles within sites. These include *newcomers* becoming *old-timers* (Wenger, 1998), *novices* becoming *experts* (Barab & Duffy, 2000) or *apprentices* becoming *masters* (Hutchins, 1993). Irrespective of the terms used to label different roles, scholars assume that membership is concerned with a trajectory of becoming more central in a practice site. Yet in some situations, participation does not require becoming an expert (or an old-timer or a master), but an adequate performer of a practice. Therefore, what is required is a perspective that conceives of participation without assuming individuals are on a trajectory from novice to becoming an expert. Unruh's (1979) social worlds typology provides such a perspective.

### 2.3.3.1 Membership in social worlds

To distinguish differences in individuals' participation Unruh (1979) proposed a social worlds typology. According to Unruh (1980 p. 271) the term social world encapsulates the imagery, processes, interaction and relationships which unite

> "a number of theoretical and empirical works [that] have appeared which are united around the notions that actors, events, practice and formal organizations can coalesce into a meaningful and interactionally important unit of social organization for participants".

The theoretical and empirical works that Unruh (1980) identified include behaviour systems, activity systems, social circles and subcultures. Given Unruh's (1980) concern for actors, events, practice and participants, membership in social worlds might be useful for understanding membership in other social sites such as cultural fields, fields of practice, communities of practice and networks of practice.

Distinguishing individuals' participation in a given social world, Unruh (1979) argued that participation in practices varies depending upon individuals' orientation, experience, relationship and commitment to that social world. He offered a typology of strangers, tourists, regulars and insiders to locate varying levels of participation that individuals can undertake with each requiring a different degree of understanding to recognise and perform the practices.

Strangers are characterised by their lack of participation in the given social world. Their inexperience sees them recognised as 'outsiders' by members of that social world. Strangers are indifferent to the ways of behaving and knowing accepted in that context. Any relationships that are formed are superficial in nature because strangers do not share similar values, norms and ways of knowing with members of that world (D. Unruh, 1979).

Tourists are characterised by their curiosity to experience social worlds that are different from their everyday one. However curiosity about different social worlds is limited to transient experiences that enable them to "know how the pieces of the social world should

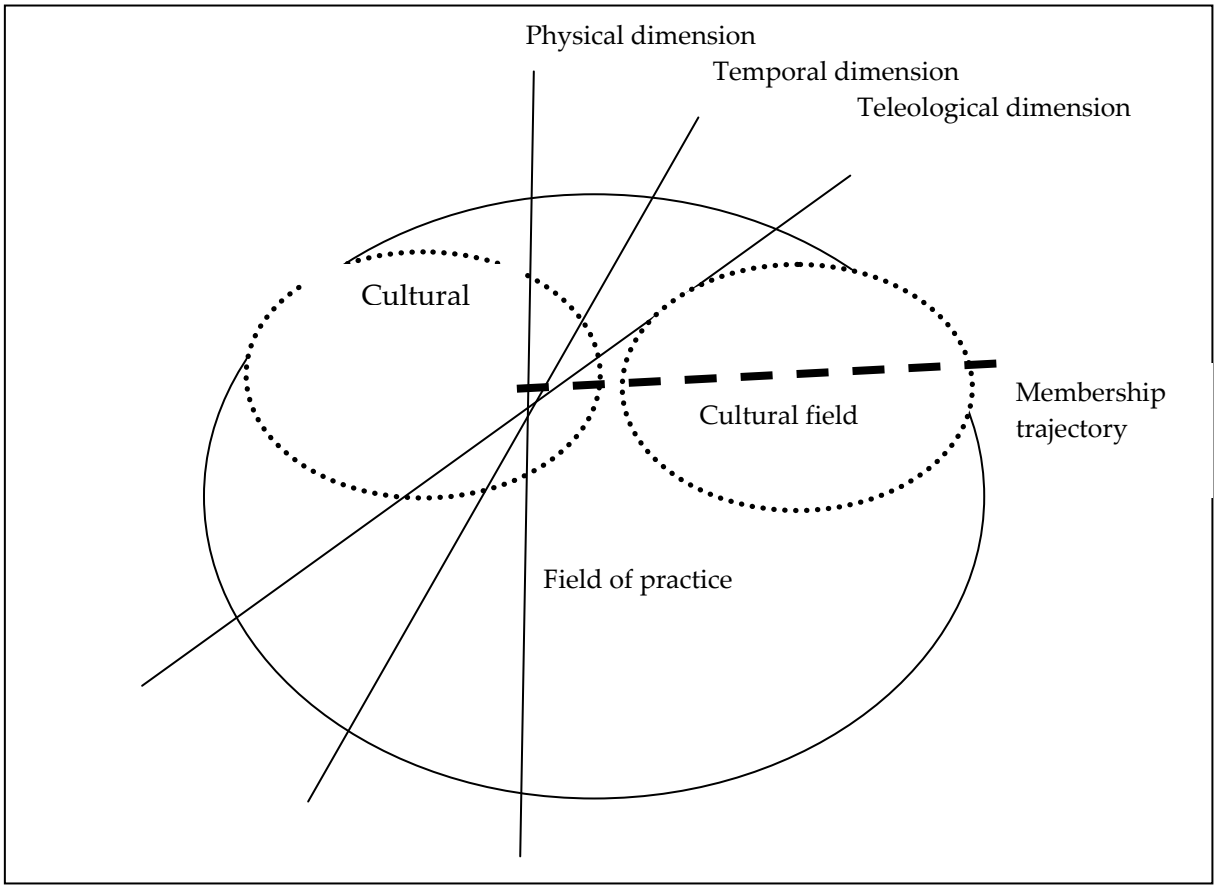
fit together ... and take it upon themselves to make minor adjustments in the social world" (D. Unruh, 1979 p. 120).

Regulars are characterised by their regular and routinised participation in a given social world. Routine participation sees them recognised as legitimate members by other individuals in the social world, but not an insider or expert. Regular participation is also characterised by a degree of understanding and commitment to the values, norms and ways of knowing in those cultural fields (D. Unruh, 1979).

The fourth type of participant in Unruh's (1979) typology is the Insider. Insiders are characterised by their knowing "the intimate details and working of a social world" (D. Unruh, 1979 p. 120). As well as their identity being closely tied to the social world, insiders are highly committed to the activities in the social world and developing close relationships with other members.

To sum up Section 3, by using Unruh's (1979) social world typology it is possible to differentiate actors' varying forms of participation in social worlds without assuming that all individuals are on a trajectory of becoming experts (see Figure 2.3). This is especially useful for examining sites of practices, such as cultural fields within fields of practice where participants are concerned with developing sufficient understandings to solve problems associated with different aspects of their work, but are not motivated towards becoming experts in those different aspects. One of the sites of practice where individuals seek to develop sufficient understandings without becoming experts are firms involved in knowledge access for innovation. In addition, by recognising the physical, temporal and teleological aspects of sites (see Figure 2.3) a more nuanced understanding of how actors navigate cultural fields for innovation might be provided.

**Figure 2.3: Conceptualising membership in cultural fields and fields of practice.**




## 2.4 Advancing practice-based explanations of learning and knowing

In this chapter I set out to survey the literature on organisational learning and organisational knowledge as important and interconnected topics that inform the research problem, *when innovation requires expertise from different knowledge domains, how do firms learn when there are few experts to learn from?* Moreover, my aim was to establish key organisational learning and organisational knowledge concepts that 1) inform the development of research questions that attend to the research problem, and, 2) guide the development of an adequate research model to address those questions.

Recognising those as well established topics, I undertook to survey three schools of thought regarding organisational learning and two perspectives on organisational knowledge. What my review established is that organisational learning and organisational

knowledge contribute importance concepts that inform the development of research questions that attend to the research problem and guide the development of a research model to address them.

Individual theories-in-action (Argyris & Schon, 1978) and personal constructs (Kelley, 1955) explain cognitive processes of individuals' learning. Use of metaphor and imagery (Crossan, et al., 1999) and other sensory information, such as images, hunches and informed guesses (Polanyi, 1967) explain social processes that enable individuals and groups to establish similar understandings. Social learning theory (Bandura, 1977) explains how these cognitive and social aspects interact through processes of observing, anticipating, imitating and modelling, in order for individuals to learn to act in socially recognized ways (Benner, 2003).

Situatedness (Lave & Wenger, 1991) explains the contextual nature of learning and knowing as a social endeavour (Gherardi, et al., 1998). In the context of firms, organisational learning can be understood as "concrete structural and procedural changes in the organization's patterns of activities"(P. Cook & Yanow, 1993 p. 375). Furthermore, as a social endeavour organisational learning can be supported by a range of activities, including socialisation and recruitment (H. A. Simon, 1991), coordination (Dodgson, 1993), knowledge integration and institutionalisation (Crossan, et al., 1999), problem-solving, implementing, importing, experimenting, and absorbing knowledge (Leonard-Barton, 1995). However, extant literature mainly focuses on learning and knowledge within the boundaries of the firm.

Since innovation is increasingly interorganisational in nature, there are important issues regarding the effect of learning and knowledge sharing processes across organisations. My literature review identified that how firms organise learning and knowing processes across geographic and relational locations for innovation are important matters. Furthermore, how geographic and relational aspects interact to influence to learning and knowing presents a further issue that is especially important when knowledge is considered as a source of competitive advantage to firms and nations.

The importance of similarity in geography is revealed in theories regarding knowledge spillovers (D. Audretsch & Feldman, 1996b; Jaffe, et al., 1993; Rosenkopf & Almeida, 2003) and channels and conduits for interorganisational communication (Owen-Smith & Powell,

2004). The importance of similarity in relations regarding knowledge domains is common across theories of relative absorptive capacity (Lane & Lubatkin, 1998), relational and cognitive dimensions of social capital (Nahapiet & Ghoshal, 1998), the nature of ties (Bell & Zaheer, 2007; M. Hansen, 1999), and, the nature of roles (Brown & Duguid, 1998; Nicolini, 2007). As well as relational and geographic aspects that influence interorganisational learning and knowledge processes, characteristics of the task (Haas & Hansen, 2005; Schmickl & Kieser, 2008; van Wijk, et al., 2008) and characteristics of individual actors are also important considerations (Andrews & Delahaye, 2000; Haas & Hansen, 2005; Lichtenthaler & Ernst, 2006).

Finally, what the literature survey establishes is that the practice-based view of learning and knowing provides an appropriate theoretical perspective to address these important research issues. First, defining practices as 'doings and sayings', which are performed in sites of practice that have physical, temporal and teleological aspects, provides a heuristic for understanding how learning and knowing occur across geographic and relational locations. Second, outlining a social world typology that recognises different types of membership in sites of practice (D. Unruh, 1979) provides a framework for exploring individuals' varying forms of participation without assuming individuals are on a trajectory of becoming experts. This is especially useful for examining sites of practices where participants' are concerned with developing sufficient understandings to solve problems associated with different aspects of their work, but are not motivated towards becoming experts in those different fields.

# 3 INNOVATION THEORIES AND MANAGEMENT PERSPECTIVES

This chapter surveys literature on innovation as an important topic that informs the research problem outlined in chapter one. That is, *when innovation requires expertise from different knowledge domains, how do firms learn when there are few experts to learn from?*

Different theoretical perspectives have long recognised learning and knowledge as important processes that underpin innovation. Because the production of new goods or services usually involves the creation and integration of different types of knowledge, learning and knowledge are core features of innovation (Howells, 2002; Kogut & Zander, 1992; Nonaka, 1994). For these reasons, a review of innovation theories and management perspectives is worthwhile to understanding existing explanations about the role of learning and knowledge for innovation. Furthermore, the review is focused on innovation as a process, recognising that innovation has been defined both as an outcome and as a process (Crossan & Apaydin, 2010; Gopalakrishnan & Damanpour, 1997). Given this, the aims of the chapter are to review innovation theories and management perspectives that 1) inform the development of research questions that attend to the research problem of accessing expertise for innovation, and, 2) guide the development of an adequate research model to address those questions.

A survey-type literature review (Huff, 2009) is relevant to establishing a comprehensive picture of innovation as a multidisciplinary topic (Fagerberg, 2005; Gopalakrishnan & Damanpour, 1997; Pavitt, 1999)(Crossan & Apaydin, 2010 p, 1174). Through a broad reading of review articles, journal special issues, and, handbooks from organisational studies, organisational economics, technology management and economic geography, my survey reveals three theoretical perspectives that contribute several important theories regarding innovation: 1) Evolutionary growth and technology management, 2) Systems of innovation, and, 3) Processes of innovation.

The three perspectives shed light on different explanations of innovation, recognising learning and knowledge as critical inputs. The first perspective, evolutionary growth and

technology, provides an evolutionary explanation of innovation that is concerned with paradigmatic changes to technological regimes and industries. These changes are path dependent with wide ranging consequences, such as competence destroying or competence enhancing technologies. The second perspective, systems of innovation, provides a dynamic explanation of innovation. Innovation is explained through evolutionary growth and interactive learning among organisations and institutions at different levels of the innovation system. The third perspective, processes of innovation, provides a processual explanation of innovation. Innovation is explained as a series of interacting processes that occur over time and within organisations. Yet, despite the proliferation of theories of innovation, some important issues remain regarding how firms organise their innovation in emerging industrial clusters and the role of individual action in the innovation process.

Given its aims, the chapter is presented in the following way. I begin by introducing innovation as a multidisciplinary topic with its theoretical roots in the work of Schumpeter. Next, three theoretical perspectives on innovation identified. These are evolutionary growth and technology management, systems of innovation, and, processes of innovation. I conclude the chapter by summarising the three perspectives and identifying gaps in the literature regarding the organisation of firms' innovation in emerging industrial clusters and the role of individuals in the innovation system.

## 3.1 Innovation: A multidisciplinary subject

As a phenomenon, innovation is not new. Examples of innovation can be seen throughout human evolution (Fagerberg, 2005). Since the 1960s, innovation has been considered a field of study, with most scholarly work on innovation occurring in the past thirty years. In its short history the innovation field has grown quickly with scholars from many disciplines contributing to the field and concurring that uncertainty is the basic precondition of innovation (Fagerberg, 2005; Pavitt, 1999). Despite this, Crossan and Apaydin (2010 p, 1174) complained in their recent meta-analysis that "innovation research is fragmented, poorly grounded theoretically, and not fully testable in all areas".

Initial interest in the topic was driven by economic concerns about long-run growth and the impact of innovation on industrial productivity (Fagerberg, 2005). Early theories were strongly informed by Joseph Schumpeter's scholarship that was undertaken some years before the establishment of innovation as a field of study. In his work on the dynamics of economic change, Schumpeter conceptualised innovation as the application of invention through the combining of existing resources (Schumpeter, 1934). This definition of innovation as a process is distinct from invention, which Schumpeter defined as new ideas.

Schumpeter's conceptualisation of innovation as resource recombination drew attention to change in capitalist economic systems. In his early work, Schumpeter argued economic change is driven by the activities of entrepreneurs (Schumpeter, 1934). In his later work he explained the importance of innovation in large firms for understanding the dynamics of economic change (Schumpeter, 1942). Described by Malerba and Orsengino (1995) as 'widening' and 'deepening' patterns, Schumpeter theorised that entrepreneurs' activities widen the innovative space through entry of new innovators who are attracted to profit-making opportunities that erode the competitive and technological advantages of established firms. At the same time, continuous innovative activities of large firms create deepening patterns that enable a few firms to dominate through their accumulated technological and innovative capabilities. From this perspective, capitalist economic systems are affected by individuals' and firms' entrepreneurial activities.

Schumpeter's notion of innovation as a process of resource combination remains a central feature of current definitions of innovation. Examples of this include Van de Ven's (1986 p. 591-2) definition of innovation as:

> "a new idea, which may be a recombination of old ideas, a scheme that challenges the present order, a formula, or a unique approach which is perceived as new by individuals involved. As long as the idea is perceived as new to the people involved it is an "innovation" even though it may appear to be an imitation of something that exists elsewhere",

and Tidd and Bessant's (2009 p. 16) definition of innovation as:

> "turning opportunity into new ideas and of putting these into widely used practice".

Both definitions capture innovation as a process of resource combination that makes use of invention. However, there are some limitations to economic growth explanations of innovation. When the economic growth perspective focuses on individuals' and firms' entrepreneurial activity, the innovation process is treated as a "black box" providing little insight into how resources are recombined to produce new products or services (Fagerberg, 2005; Rosenberg, 1983). By concentrating on long run change in capital economic systems, economic growth perspectives do not consider the influence of other industrial or institutional contexts operating alongside entrepreneurial action (Edquist, 2005).

Since the 1990s, interest in innovation has been driven largely by new debates regarding knowledge as the basis for economic and social wealth creation. These debates have taken a number of forms. Recognising changes in society, notions of knowledge economy (Beck, 1992), knowledge society (Giddens, 1990), and knowledge-based development (Carrillo, 1997) were proposed to highlight the role of knowledge production for innovation and economic growth as responses to increasing competitive pressures. These debates coincided with similar discussions in organisational spheres about knowledge work (Drucker, 1993) and knowledge based view of the firm (R.M. Grant, 1996a; Spender, 1996a) as critical factors or sustained organisational performance. Throughout this time a multidisciplinary approach has remained a common feature of innovation research (Fagerberg, 2005).

Given the recent but frantic growth of literature about innovation, this survey concentrates on two issues:

1. How innovation (as a process) has been conceptualised, and,
2. The relationship between learning, knowledge and innovation.

To capture its multidisciplinarity the issues are considered in relation to three perspectives:

- Evolutionary growth and technology management where scholars take a broad interest in innovation about the nature and sources of technological change as explanations of economic growth. This body of literature seeks to explain differences in technical change within and across industries and firms.
- Systems of innovation where scholars' approaches emphasise the dynamics of innovation and economic transformation. Knowledge and learning are dynamic

elements both resulting from and contributing to innovation at different levels of the system.

- Processes of innovation where scholars are concerned with firms' organising of innovation, including search and selection processes. Recognising knowledge as a basis for competitive advantage, these scholars are concerned with individual and organisational actions that support firms' innovation.

## 3.2 Evolutionary growth and technology management

In the evolutionary growth and technology management perspective, innovation can be conceptualised as firm-specific technologies developed within wider technological regimes(C. Freeman & Soete, 1997). From this perspective the purpose of evolutionary growth and technology management theories are to explain why technological innovation was the major contributor to economic growth over the 19th and 20th centuries (G. Dosi, 2000).

According to Pavitt (1999) the evolutionary growth and technology management perspective starts from two premises that relate learning and knowledge to innovation. The first one is that technological knowledge cannot be reduced to scientific knowledge or information. In line with this premise Dosi (1982, pp. p. 151-152) defined technology as

> "a set of pieces of knowledge both directly practical and theoretically applicable although not necessarily ready, know-how, methods, procedures, experience of successes and failures and also physical devices and equipment".

The second and related premise is that knowledge is costly due to the learning investments that firms must make in order to develop sufficient problem-solving capacity (Pavitt, 1999). The premise that knowledge is costly is built on Simon's (1957) bounded rationality principle, which assume that cognitive limitations of individuals restrict learning dynamics and knowledge possibilities in the way problems are solved (G. Dosi, 2000). Thus, from the evolutionary growth and technology management perspective, technology equates to knowledge and learning is necessary to producing technology, which supports firms'

technological development. However, firms' learning is influenced by wider technological patterns.

Technological regimes define the nature of problems that firms face and shape their incentives and constraints for future learning (Malerba & Orsenigo, 1997; R. Nelson & Winter, 1982). As technological change requires mechanisms for generating technological alternatives, and methods for screening, testing, evaluating and diffusing them (R. R. Nelson, 1986), firms' heterogeneous learning processes, generate knowledge variation. However most knowledge applied by firms for innovation is, used for specific purposes and is appropriated in specific forms. Firms cannot, and do not, identify and evaluate all information possibilities equally because they are constrained by their existing knowledge (Rosenberg, 1983). Changes in technological regimes depend upon firms' knowledge base and artefacts as sources of technological innovation (Giovanni Dosi, 1988; R. R. Nelson, 1986; D. J. Teece, 1982).

Recognising that changes in technological regimes are usually characterised by periods of firms' experimentation, Henderson and Clark (1990) argued even innovations that involve small changes to existing technology can have dramatic competitive consequences. They argued that systemic configuration of bundles of knowledge brought together from multiple technologies and markets result in an innovation architecture that can destroy technological regimes. Using the innovation architecture principle, Henderson and Clark's (1990) analysis of new product development in the semiconductor photolithographic alignment equipment industry showed changes within the innovation process can challenge firms' organisational capabilities. Henderson and Clark (1990) concluded that it is difficult for firms to recognise and remedy potentially damaging systematic changes because these are often beyond firms' expertise. This presents a challenge to how firms can organise their innovation so they are more cognizant of changes in technological regimes and how firms' technologies can respond to those changes.

Concerned with differences in the evolution of innovation, some scholars have concentrated on explaining changes within sectors. The purpose of these theories is to explain why innovation occurs through the co-evolution of technological regimes that vary across sectors and firms' knowledge bases (Malerba, 2005). In his seminal paper, Pavitt (1984) proposed a sectoral-based theory to explain patterns of technical change. Using a

database of 2000 significant British innovations from 1845-1979, Pavitt (1984) proposed a sectoral taxonomy of supplier-dominated, production-intensive and science-based firms. Using evolutionary growth arguments, Pavitt explained three sectors according to differences in the sources of technology used for innovation, variation in the nature of the technology produced by innovating firms, by size and principle activities of innovating firms.

According to Pavitt's (1984) taxonomy, supplier-dominated firms are found mainly in traditional manufacturing work. They are generally small with weak R&D capabilities. They appropriate little value through technological advancement and rely heavily on suppliers to improve inputs for firms' innovation. These characteristics put supplier-dominated firms on a technological trajectory defined by cost-cutting.

The second category in Pavitt's taxonomy is production-intensive firms. These firms have size due to division of labour and technical specialisation that enables machine substitution for some labour costs. Practical know-how regarding products and their production is important, which makes intra-firm learning important for improving production aspects of firms' innovation process.

The third category in Pavitt's taxonomy is science-based firms. In Pavitt's original study, this category included chemical and electronic firms. Subsequent research using Pavitt's models place biotechnology firms in this category as well (Malerba, 2002; Malerba & Orsenigo, 2002). Science-based firms use R&D from their sector and from universities to develop new technologies based upon prior knowledge. Science-based firms appropriate value through a mix of methods that aim at protecting knowledge specialisation. Given these characteristics, technological trajectories are towards specialised professional applications within the sector.

Pavitt's (1984) sectoral model of innovation makes a number of important contributions to understanding the patterns and direction of technical change (Malerba, 2005; Malerba & Orsenigo, 1997). First, it showed that different forms of innovation effect the direction of technical change. Specifically, when technology matures sectors may shift from being production-intensive towards supplier-dominated. Second, it showed that rate of change is an important explanatory variable of prevailing patterns of technological change. Third, in describing knowledge specialisation of science-based firms, it explained the increasing

challenges these firms face in remaining cognizant of changes in technological regimes. Fourth, it showed that factors leading to innovation and its appropriability vary across sectors, reinforcing the premise that idiosyncrasies in the knowledge base of firms are important to understanding differences in organisational performance.

Building upon Pavitt's work some scholars proposed life-cycle models to explain why technological change varies. Some scholars linked patterns of technological change to industry life-cycles, while other scholars have linked patterns of technological change to cluster life-cycles. The purpose of industry life cycle models (section 3.2.1) and cluster life cycle models (section 3.2.2) and their explanations of the learning-knowledge-innovation relationship are considered next.

### 3.2.1 Industry life cycle approaches

According to Malerba and Orsengino (1995 p. 48) industry life cycles follow a general pattern whereby

> "early in the history of an industry, when technology is changing very rapidly, uncertainty is very high and barriers to entry very low, new firms are the major innovators and are the key element in industrial dynamics. However, when an industry develops and eventually matures and technological change follows well-defined trajectories, economies of scale, learning curves, barriers to entry and financial resources become important in the competitive process and large firms with monopolistic power come to the forefront of the innovation process".

Industry life-cycle models are premised on the assumption that knowledge is a critical input for innovation. Knowledge is an important input for innovation because the production of new goods or services usually involves the integration of different types of knowledge (Howells, 2002). Knowledge production and knowledge sharing processes differ across the industry life-cycle depending on the number of firms and the nature of them.

Klepper (1997) questions of who innovates and how much are linked to industry life cycle stage. Based on his analysis of the US automobile industry, he proposed a four-stage model of entry, growth, maturity and decline. New firm entry is greatest during the formation of

an industry when highly innovative small firms are attracted to new opportunities with low cost of entry. At the growth stage, industry growth is driven by highly innovative large firms who use profits from earlier innovation to fuel ongoing development. At this stage, new entrants face significant barriers to entry because they have to compete with the knowledge base of larger incumbents. By the maturity stage, innovation activity has fallen and continues to be dominated by large firms. There are fewer opportunities for all firms, leading to 'shakeouts' among incumbents. The final stage is maturity where low levels of innovation are generated by small firms who seek niche improvements from a contracting opportunity space. In summary opportunities within the industry are influenced by firms' innovation.

### 3.2.2 Cluster life cycle approaches

While some scholars linked clustering to industry life cycles, less concern has been shown to the influence of cluster life-stage (Swann, Prevezer, & Stout, 1998). Recently this has led to a number of scholars calling for closer attention to cluster life-cycles. These scholars concur that evolutionary growth follows a life-cycle because of the characteristics of knowledge. This is because the knowledge resources that clustering provides differ across life-cycle stages, thus influencing the opportunities for innovation. However, due to the geography of innovation, these scholars claim that clusters experience life-cycles that differ from industry life-cycles.

Because of geographic proximity among organisations, industrial clusters, which are defined as "geographic concentrations of interconnected companies and institutions in a particular field"(Porter, 1998 p. 78), are commonly associated with innovation. Porter (1990) argued that due to domestic rivalry, inputs from buyers and efficient transmission of new ideas, industrial clusters are important for organisational improvements and technological innovation s. Krugman (1991) argued that interactions in local markets produce increasing returns that reinforce agglomeration patterns of local labour markets, intermediaries, and, knowledge spillovers.

The relationship between evolutionary growth and cluster life cycle has been suggested by a number of scholars (Bergman, 2007). Pouder and St. John (1996) argued that

agglomeration and institutional forces encourage clustering of firms for innovation whereas the creation of macrocultures can suppress clustering. Macrocultures discourage clustering because incentives to innovation are suppressed. Baptista (1998) argued that supply-side factors of skilled labour, intermediaries and new idea sharing have demand-side effects that create congestion. Congestion effects, such as increased real estate and labour costs and increased competition can make co-location less attractive to new entrants. Bresnahan et al's (2001) two-year study of regional clusters in a number of different countries found factors that gave rise to clusters were different from those that sustained them. Studies of cluster success (Saxenian, 1994; Swann, et al., 1998) and failure (Orsenigo, 2001) suggest that clusters follow their own life cycles, and ought to be theorised accordingly. Given this, Maskell and Kebir (2005) argued that more robust concepts are needed to explain processes beyond clusters' establishment.

To explain clustering processes, Menzel and Fornahl (2010) theorised a four stage cluster life-cycle theory. Each cluster stage is characterised by differences in the number of firms, number of employees and the nature of the localised knowledge base. Given that each cluster life stage presents different characteristics, it can be assumed that innovation activities will differ across the stages.

Emerging clusters that often operate in new industrial sectors such as biotechnology are characterised by young knowledge-based firms in the early stages of development. Typically, emerging clusters will have few firms with a lasting vision for a new local technology path. They often have favourable local scientific and political conditions to support cluster growth to a critical mass, but lack of experience, a small skilled labour market due to few workers having been employed, and, heterogeneity of technology (Menzel and Fornahl, 2010). As there are a small number of individual and organisational actors, these characteristics culminate in weak conditions for localised learning and knowledge sharing. Those few actors are likely to share limited cultural fields due to heterogeneity of technology.

In contrast, established clusters experience strong growth through existing firms and new start-ups. They are characterised by a strong knowledge infrastructure that includes stakeholder organisations and other institutions that support firms' innovation. Firms are oriented towards collaborating with other local firms, which in terms of technological

homogeneity make the boundaries of the cluster more definable (Menzel and Fornahl, 2010). These characteristics provide strong conditions for localised learning and knowledge sharing because there are large numbers of individual and organisational actors. There is some knowledge homogeneity; hence, that increases the likelihood at collaboration among actors.

To summarise section 3.2, the purpose of the evolutionary growth and technology perspective is to explain firms' innovation in relation to broader technological regimes. While technological regimes influence what problems firms' address, the technologies produced by firms' learning and knowledge processes influence the technological regime. This highlights the role of knowledge as a core input for innovation. Furthermore, industry and cluster models provide different explanations about the effect that external environment has on firms' innovation.

## 3.3 Systems of innovation

The second perspective on innovation is systems of innovation. The purpose of this perspective is to describe, understand and explain factors that influence innovation (Edquist, 1997). To achieve this, scholars draw on evolutionary growth and interactive learning theories to explain the "economic, social, political, organisational and institutional factors that influence the development, diffusion and use of innovation" (Edquist, 2005 p. 182). However, these scholars differ in their levels of analyses of the innovation system, which is reflected in the range of systems-based theories. In this section, I review the purpose of the systems of innovation perspective by outlining three common assumptions. To review how the systems of innovation perspective explain the learning, knowledge and innovation relationship, I review scholars' evolutionary growth and interactive learning arguments, and how these are applied at different levels of the innovation system.

First, scholars of the systems of innovation perspective assume firms' innovation does not occur in isolation; firms' innovation is embedded in:

> "a network of organisations, individuals and institutions which determine and shape the generation, diffusion and use of technology and other knowledge, which, in turn,

explain the pattern, pace and rate of innovation and the economic success of innovation" (B Lundvall, 1992 p. 10).

Wider systems are the result of historical actions that produce an evolutionary path (R. Nelson & Winter, 1982). Secondly, the systems of innovation perspective assumes the function of any innovation system is to pursue innovation (Edquist, 2005).

Third, organisations and institutions play important roles in the innovation system. Organisations refer to formal structures that are consciously created for a purpose (Edquist, 2005). For systems of innovation scholars, organisations of interest are those known to influence firms' innovation. Given the concerns with understanding how innovation systems can be influenced, there is a robust scholarly interest in the activities of organisations involved in public policy as a method of influencing innovation. These include government and its agencies, universities, public science units, and, not-for-profit societies. Institutions refer to sets of common habits, norms, routines, established practices, rules and laws that regulate relations and interactions between individual, groups and organisations (Edquist, 2005). As institutions are the result of historical patterns of activities, systems of innovation scholars' interest can depend upon the level of the innovation system where institutions have evolved.

### 3.3.1 Evolutionary growth of innovation systems

To understand innovation and its effects, scholars explain innovation in terms of evolutionary growth (Edquist, 1997). As outlined under the evolutionary growth perspective in section 3.2, a central finding of the evolutionary growth perspective is that firms' innovation interacts with external factors. External factors and technological regimes influence the types of problems firms address and the methods used for solving them. At the same time, firms' knowledge bases influence their ability to understand changes in technological regimes and respond to them. Based upon this, the systems of innovation perspective is concerned with understanding relations between the various factors operating in broader systems that influence firms' innovation.

### 3.3.2 Interactive learning in innovation systems

As well as evolutionary growth theory, systems of innovation scholars explain innovation as the result of interactive learning (Edquist, 1997). Starting from the premise that knowledge is the fundamental resource in modern society, Lundvall (1992) claimed that learning has become the key to firms' performance as it is crucial to firms' knowledge acquisition.

Taking a broad definition of learning as including practical skills established through learning by doing, new insights produced by R&D, as well as capabilities acquired through formal education and training, Lundvall and Borras (1997) argued that learning leads to growth in the stock of knowledge that support firms' innovation. However, the rate and direction of learning is influenced by the different skills and of types of knowledge brought to the learning process. In recognising learning as a social endeavour, the nature of relations influences the learning process. For these reasons Lundvall (2010) claimed all learning processes are interactive.

Rhonde and Hussler (2005) argued that internal and external learning has different roles in interactive learning processes. Internal learning supports the production and sharing of technical knowledge within the firm, whereas external learning supports the development of relational knowledge that enables firms to access knowledge from other organisations. Testing the role of internal and external learning on econometric data from a survey of 5000 French manufacturing firms, Rhonde and Hussler (2005) found statistical support that firms' relational knowledge gained from external learning is most important for firms' innovation performance. These authors concluded that while interactive learning processes involve internal and external learning, external learning is the more important process.

In contrast to Rhonde and Hussler (2005), Gertler and Levitte (2005) found that in-house technological capability and absorptive capacity developed through internal learning are important determinants of successful innovation. Focusing on the Canadian biotechnology industry, Gertler and Levitte (2005) examined the role of internal resources and capabilities of the firm, as well as local and global flows of knowledge and capital. Analysing data from Statistics Canada's 1999 Survey of Biotechnology Use and Development and data on patenting activity, they concluded internal and external learning are equally important for

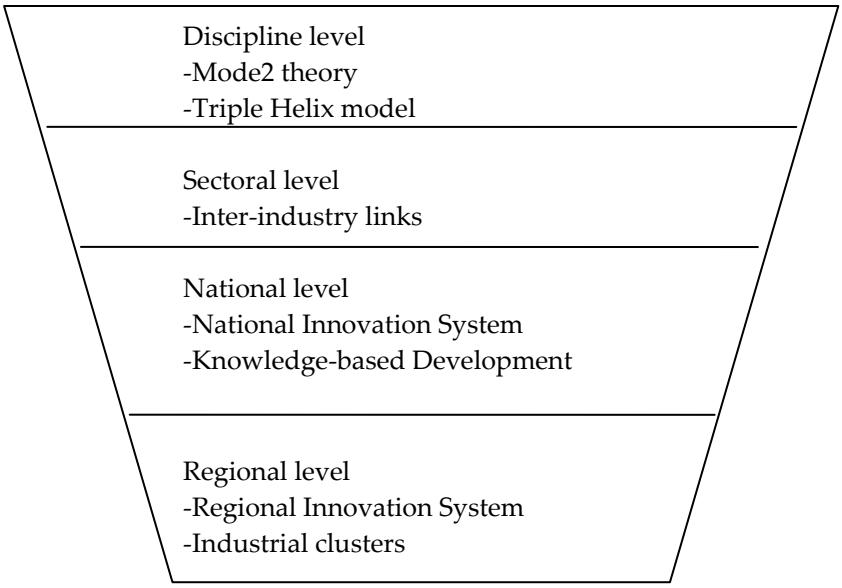
innovation. In addition, they showed that internal learning relates to local arrangements whereas external learning relates to global networks.

In summary, the purpose of the systems of innovation perspective is to explain the complex interactions among multiple stakeholders whose evolutionary growth and interactive learning produce innovation. Given the complexity in the innovation system, scholars have concentrated their analysis on different parts of the system.

### 3.3.3 Levels of analysis in the innovation system

In order to examine how evolutionary growth and interactive learning produce innovation, groups of scholars have tended to concentrate on certain levels of the innovation system. Focussing on different parts of the innovation system has led to a range of theories that differ in their level of analyses (Edquist, 1997). By categorising these theories, it is clear there are four levels of analysis (See Figure 3.1). While some empirical studies demonstrate that demarcation of systems' boundaries are difficult to define (Carlsson, Jacobsson, Holmén, & Rickne, 2002) these analytic approaches do provide a useful way of understanding the different ways scholars explain the relationships of learning, knowledge and innovation.

**Figure 3.1: Levels of analysis in the innovation system.**



### 3.3.3.1 Discipline-based approaches

**Mode 2 approach to new knowledge production.**

Gibbons et al.(1994) theorised changing modes of knowledge production as a Mode 2 model that operates alongside the Mode 1 model of traditional disciplinary structures. They describe the world's knowledge production as emerging from processes that increasingly operate within contexts where knowledge production is directly applicable to localised problems. Given demands for applicable knowledge for localised problems, knowledge processes are increasingly organised in non-hierarchical and heterogeneous forms that evolve according to local needs. Furthermore, knowledge processes involve many actors throughout the process. These actors can include firms, universities, research laboratories, think tanks, and consultants.

Instead of relying on dominant science and technology institutions and being governed by strict disciplinary norms (Knorr Certina, 1999), Mode 2 theory draws attention to multiple institutions that govern knowledge processes. The shift towards networked knowledge production has significant implications for the scientific institutions as well as the norms and processes associated with knowledge production. Rather than exclusively expert-based, strictly discipline-bound and largely self-referential, networked science production transcends disciplinary and institutional boundaries (Nowotny et al., 2001).

Networked knowledge production influences institutions in the innovation system. Given that (re)negotiation and (re)shaping of research agendas involves interaction among stakeholders in localised contexts, new knowledge is governed by different and sometimes competing institutions (Gibbons et al., 1994). According to Notwotny et al (2003) some organisations see Mode 2 as a means to influencing what institutional mechanisms are used to govern knowledge production. In particular, governments seek to use Mode 2 as a method for creating better mechanisms to link science with innovation. In contrast, organisations associated with the traditional science institution perceive Mode 2 as a threat to the quality and autonomy of new knowledge production.

**Triple Helix.**

To explain the effects of changing institutional patterns Etzkowitz and Leydesdorff (Etzkowitz & Leydesdorff, 2000) proposed the Triple Helix model. Recognising the

complexity of historical dynamics on the innovation system, Leydesdorff and Meyer (2006) claimed that innovation can be understood by examining the co-evolution and mutual shaping of three institutions: industry, university and government. They argued these institutions are central because they operate under different selection environments that influence what governance mechanisms are used. Specifically, industry is oriented towards wealth generation, university is oriented towards novelty, and government is oriented towards public control. In this way the Triple Helix provides a normative description of how 'industry', 'university' and 'government' can engage in more systemic interaction for greater scientific involvement in innovation (Etzkowitz & Leydesdorff, 2000).

### 3.3.3.2 Sector-based approaches

Sectoral approaches assume that different industries may have different competitive, interactive, and organisational boundaries that stretch across institutions and nation states (S Breschi & Malerba, 1997). A main principle of the sectoral approach is inter-industry links are key factors for innovation. Due to technological interdependence inter-industry links are claimed to be important because innovation in one industry can provide inputs into production processes of other industries (Carlsson & Stankiewicz, 1991; Pavitt, 1984). Given that scientific and technological fields vary across sectors (Malerba, 2005), inter-industry links connect organisations from knowledge domains with different competencies.

From a sectoral approach, conditions that facilitate learning and knowledge processes between organisations can be provided by industrial clusters and networks (Carlsson & Stankiewicz, 1991; Porter, 1998). For this reason evolutionary growth explanations of industrial clustering reviewed in section 3.2 are also relevant to sectoral systems explanations of innovation. Specifically, in early stages co-location can support tacit knowledge sharing between firms from different sectors. However, sectoral approaches recognise that industrial clusters are embedded in broader sectoral systems.

Given industrial clusters are embedded in broader sectoral systems, the specific knowledge base and types of organisations and institutions involved in a sectoral system can influence activities within industrial clusters. This is because the cumulative nature of knowledge influences organisations' ability to use technologies from other knowledge

domains (Malerba, 2005). Furthermore, the social structures generated within a sector and reflected in the sector's institutions affect organisations' activities within industrial clusters (Malerba, 2002).

The influence of sectoral-based structure presents challenges in new industrial clusters where clusters span multiple sectors, such as biotechnology (Mowery & Nelson, 1999). Biotechnology involves complex, interactive chains of transactions among scientists, entrepreneurs, and various intermediaries, including investors and lawyers (P. Cooke, 2002a). According to Malerba (2002) in these instances knowledge bases and technologies from the different sectors must be integrated and new relations formed among different types of users, consumers, firms, organisations and institutions.

While some interactions are shown to occur under institutional proximity, such as relations between university scientists and firms working with early-stage science, other interactions occur at institutional distance (P. Cooke, 2002a). These can include relations between firms and investors, regulatory agencies, and, research hospitals for clinical trials (Pisano, 1991). Given this, biotechnology can be better understood as a field where organisations engage in common activities and are subject to varying institutional pressures (Powell, White, Koput, & Owen-Smith, 2005 p. 1134), rather than as a single sector.

### 3.3.3.3 Nation-based approaches

**National Innovation Systems**

From the National Systems of Innovation approach, Lundvall and colleagues (1992; 2010; B. Lundvall & Borras, 1997) argued that innovation is facilitated by legal systems controlled by one a central state, national culture and language. Legal systems, national culture and language are institutions, which are the result of a nation's evolutionary history. As institutions, they create conditions for interactive learning among organisations. From this perspective, institutional and geographic boundaries are important for understanding learning and knowledge in the innovation system.

Given that institutions create conditions for interactive learning, Lundvall (1992) suggested that national differences may be reflected in the innovation systems in different ways. These include the internal organisation of firms, inter-firm relationships, the role of

public sector, and the organisation of R&D and its intensity. Nelson's (1993) description of national innovation systems of thirteen countries and Freeman's (C Freeman, 1988) historical review of Japan's national innovation system provided empirical evidence of major differences among countries regarding the organisation and development of innovation within national economies.

**Knowledge-based development**

Related arguments regarding the interaction between actors engaged in knowledge-related processes are proposed in the knowledge-based development approach. Rather than a static understanding of knowledge as stocks, the knowledge-based development approach pays attention to understanding how dynamic knowledge-related processes operating across various institutional contexts can be influenced by government (Carrillo, 2002). The focus on role of government reinforces the geographic boundaries of nations.

Recognising that global and local contexts interplay (Carrillo, 2009), it can be expected that an increasing heterogeneity of views and opinions will be promulgated in the innovation system. While various actors' views and opinions are valid, they are likely to be competing. Different institutions governing the various actors' views are likely to compound disputes and contestation contributing towards further complexity in the innovation system.

In response to complexity of knowledge based phenomena, the knowledge-based development approach proposes that in order to develop effective innovation systems it is necessary to understand the interaction among actors who are involved with transforming global knowledge into local development (Knight, 1995). Specifically the knowledge-based development approach proposes strategic action on the part of governments and their agencies to facilitate and co-ordinate the process of constructing a stronger knowledge base for individuals and firms at national and regional levels (Mansell, 2002).

### 3.3.3.4 Region-based approaches

**Regional Innovation Systems**

Regional Innovation Systems scholars argue that regions are important bases of economic coordination as they draw attention to governance processes operating between the national

level and the individual firm (Asheim & Gertler, 2005; Asheim & Isaksen, 2002; P. Cooke, Uranga, & Etxebarria, 1997). Lawson and Lorenz (1999) argued the evolutionary and interactive nature of learning and knowledge in regions provides a competitive advantage that cannot be transferred to other regions.

According to Cooke et al. (1997) regional competitive advantage can be facilitated by three components: financial capacity, institutional learning, and productive culture. Financial capacity refers to the degree of regional governments' financial jurisdiction and banking control, which can be directed towards improving relations between parties by minimising funding uncertainties. Institutional learning refers to the means and incentives that encourage individual and organisational learning regarding acceptance of institutional change, which enables firms to respond to changes in the innovation system. Productive culture refers to common values regarding cooperation, ability and experience to carry out institutional change, coordination among public and private activities, and communication among different scientific, technological, productive and financial fields. From this perspective, geographic boundaries of regions are important to understanding learning and knowledge for innovation.

**Industrial Clusters**

Regional systems recognise the role of the industrial clusters in explanations of regional innovation (Asheim & Gertler, 2005). In particular, the success of regional innovation areas such as Silicon Valley's ICT industry (Saxenian, 1994) and Boston's biotechnology cluster (Powell, et al., 2002) raised scholarly interest in the relationship between regions and clustering.

Industrial clusters can connect individual and organisational actors in order for them to gain access to external knowledge for innovation (B. Lundvall & Borras, 1997; Malmberg & Maskell, 2006). Audrestch and Stephan (1996) argued the clustering in biotechnology is shaped by firms need to communicate with scientists for tacit knowledge sharing. Using patent data to measure spatial-based incidence of contacts between biotechnology firms and university-based scientists affiliated with these firms, they demonstrated a relationship between biotechnology firms' co-location to collaborating scientists.

Zucker et al's (1998) study of biotechnology start-ups during the 1990s found firms spatially clustered around 'star scientists' who provided R&D expertise and market signals that were not easily accessed from other parts of the industry. Studying interorganisational arrangements in the Boston biotechnology region Owen-Smith and Powell (2004) found similar patterns. They concluded that geographical proximity enables firms to use face-to-face interaction, which makes information-sharing more efficient and provides faster access to knowledge spillovers.

Industrial clusters and regional innovation systems research about the relationship between learning, knowledge and innovation is best summed up by Asheim and Isaksen (2002 p. 9):

> "The crux of the argument is that the proximity between different actors makes it possible for them to create, acquire, accumulate and utilise knowledge a little faster than firms outside of knowledge intensive, dynamic regional clusters".

### 3.3.4 Need for a multi-level approach to innovation systems

Despite the efforts of scholars to examine different levels of the innovation system, there remains a gap in explaining how the more macro-levels of the innovation system influence, and are influenced by, the more micro-levels. The fact that knowledge is not just "out there" for firms to acquire, but that it is situated (Lechner & Dowling, 2003), requires scholars to consider how firms innovate through their individual employees' expertise (Lorentzen, 2007).

Given it is through membership to relevant epistemic communities that individuals are able to access expertise, it is individuals' location in those epistemic communities that affects innovation (Hakanson, 2005). Based on this Hakanson (2005 p. 434) called for future research to concentrate on the role of the individual actors in the innovation process:

> "Shifting the unit of observation from the firm to individuals as economic agents provides a different perspective on innovation and entrepreneurship and puts in a different light the nature of the advantages that clusters may provide".

According to Coleman (1990) relating social phenomena, such as innovation, across levels of the system is a central problem in social science of explaining collective outcomes with individual action. To address this the multi-level analysis of innovation systems needs to be extended to include the micro-foundations of individual action (Nooteboom & Stam, 2008).

### 3.3.4.1 Relational-based approach

A relational-based approach is useful to analysing the role of individuals in the innovation. Relational proximity refers to closeness of relations in terms of norms, values and rules of thought and action (Coenen, et al., 2004). These aspects of relational location highlight the situated nature of practices, which are concerned with the different ways of knowing (Amin & Roberts, 2008). Relational proximity is referred to by some authors as institutional proximity or social proximity (Knoben & Oerlemans, 2006). However, Boschma (2005) convincingly argued that these are separate forms of proximity, which should be separated to aide conceptual clarity.

While relational aspects have been explored in the practice-based view of learning and knowing (see chapter 2), systems of innovation scholars have paid less attention to it. This is unfortunate because exploring relations provides a way of examining individuals' actions in the innovation system. Relational proximity is important because it assists actors recognise and value practices that are performed in different fields of practice (Amin & Roberts, 2008). While actors cannot share exactly the same meanings, similar mental models provide common understandings about 'how and why' things are done (Turner, 1994). During innovation, similarities are known to act as a selection heuristic that reduces uncertainty and risk (Podolny, 1994). Therefore, relational proximity is likely to influence individuals' actions during the innovation process.

To summarise section 3.3, the purpose of the systems of innovation perspective to describe, understand and explain factors that influence innovation (Edquist, 1997). Scholars draw on evolutionary growth and interactive learning theories to explain the "economic, social, political, organisational and institutional factors that influence the development, diffusion and use of innovation" (Edquist, 2005 p. 182). While evolutionary growth and interactive learning provide common explanations of innovation, they have been applied to

analyse different levels of the innovation system. In analysing the different levels of the innovation system, institutional and geographic boundaries are highlighted as important to understanding learning and knowledge for innovation. However, the lack of micro-level analysis suggests the systems of innovation perspective can be advanced by exploring the role of individuals. Furthermore, the relational approach provides a theoretical perspective for understanding individuals' action.

## 3.4 Processes of innovation

The third perspective addresses the processes of innovation. To understand how innovation is organised and how it might be managed this perspective looks into the innovation 'black box' of what happens inside firms (Fagerberg, 2005). In this section, the purpose of innovation according to the processes perspective is reviewed by outlining a number of models that conceptualise innovation within the firm. Then the relationship between learning, knowledge and innovation is surveyed by focussing on search and selection as critical processes for firms' innovation.

### 3.4.1 Linear process models

A number of models have been proposed to describe firms' innovation. Generally, these have evolved from being linear towards being more interactive. Early models assumed a technology-push whereby basic science generated new ideas that would be pushed towards firms who developed them for unspecified markets (Mowery & Rosenberg, 1979; Roy Rothwell, 1992). By the late 1960s, these were being revised as market-pull models in which market needs directed firms' development activities. In both push/pull approaches, direction of innovation was one-way.

Linear approaches were also used in some of the New Product Development literature. Stage-gate models aim to provide a blue print to direct and accelerate product innovation efforts through a series of critical success factors. Stage-gate models use gates as symbols representing events that firms use to decide whether new product projects continue

(Cooper, 2001). Although stage-gate models have been through a number of iterations, (Cooper, 1994), the basic tenant that sequential stages in the innovation process can be managed remains unchanged.

A linear approach was also applied to funnel and pipeline-type models that assert managerial attention and influence is greatest at the beginning of the innovation process (Wheelwright & Clark, 1992). According to this approach, managers' efforts should focus on creating, defining and selection stages of the innovation process.

Linear models of innovation have been criticised for a number of reasons. First, linear models generally ignore the influence that technological regimes have on firms' learning and knowledge processes (Rosenberg, 1983). They also ignore the broader innovation systems that firms operate in, suggesting innovation is too complex to be described as linear (Mowery & Rosenberg, 1979). Secondly, in concentrating on basic science, linear approaches overplay the role of scientists in generating new ideas, underplay the role of applied research and development in ongoing testing and refining throughout the innovation process (Kline & Rosenberg, 1986). Kline and Rosenberg (1986) go on to say these inaccuracies are due to the absence of feedback paths at the different stages of innovation.

The third limitation regards inadequate explanation of screening and assessment activities that occur during innovation. Often innovative ideas go through substantial transformation that change their economic significance to the firm (Kline & Rosenberg, 1986). Linear models that explain innovation as isolated stages ignores potential architectural level changes within the firm (Henderson & Clark, 1990). In response to this criticism, chain-linked models have been proposed that explain innovation as chain of activities and feedback links that recognise where uncertainty can occur (Kline & Rosenberg, 1986). However, a causal tendency is still assumed.

Linear models tend to be internally oriented relying upon internal staff to make such judgements. These types of internal processes assume that firms have the best people all of the time. This is a highly problematic assumption when growth in new start-up firms and the mobility of the growing university-educated labour market is considered (Chesbrough, 2006a). This raises issues of how ideas are treated in decision-making processes regarding their future resourcing, and, where and how they might be integrated with firms' existing knowledge (Chesbrough, 2006b).

### 3.4.2 Interactive process models

In an attempt to address the issue of describing the complex interactions involved with innovation, Rothwell and Zegveld (1985) proposed an interactive model, which they describe as

> "a logically sequential, though not necessarily continuous process, that can be divided into a series of functionally distinct but interacting and interdependent stages. The overall pattern of the innovation process can be thought of as a complex net of communication paths, both intra-organisational and extra-organisational, linking together the various in-house functions and linking the firm to the broader scientific and technological community and to the marketplace. In other words the process of innovation represents the confluence of technological capabilities and market needs within the framework of the innovating firm"( p. 50).

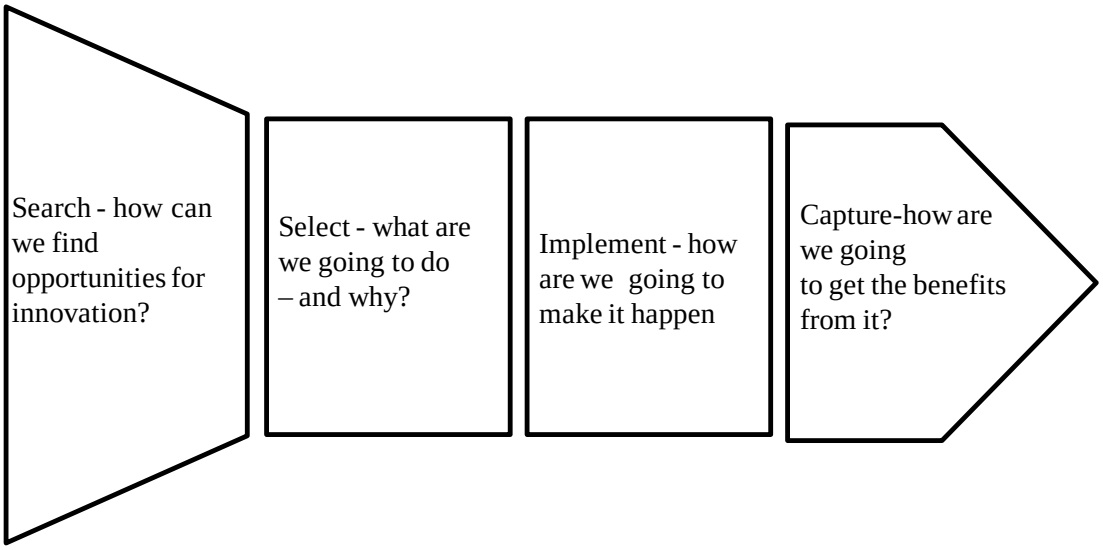
Hargadon (2002) proposed a similar process-oriented model of innovation that describes innovation as knowledge brokering process. Arguing that knowledge brokering is more than developing network ties, Hargadon (2002) argued innovation involves accessing, bridging, learning, linking and building processes. Access is concerned with the knowledge from different social worlds that can be recombined. Bridging describes the strategies individuals use to move resources between different social worlds. Defining learning as "the activities that individuals engage in to bring knowledge from a particular domain into the organization"(Hargadon, 2002 p. 49), learning is concerned with bringing knowledge from a particular social world to the firm. Linking concerns how individuals recognize that sharing old resources can address new situations. Building addresses how innovation in a particular situation can become more widely accepted in the firm.

Recognising innovation as "a core set of activities distributed over time ... that is rarely a single event but cycles of activities repeated over time" (p.79) that "has become an open process involving richer networks across and between organizations" (p148), Tidd and Bessant (2009) described innovation as a process involving four sub-processes (see Figure 3.2). Searching involves scanning internal and external environments for signals about

opportunities and threats. Selecting concerns decisions regarding what signals gain a response. Implementing involves the translation of selected ideas into innovation outputs. Capturing value is concerned with financial and non-financial value that firms can secure in order to sustain its future innovation activities.

Regarding interactive models that describe the innovation process, there are some common themes about learning and knowledge. These regard the integrated relationship between learning, knowledge and innovation, the different reasons for learning in innovation, the increasing external orientation of learning and knowledge processes for innovation, and, the role of individuals in firms' innovation.

**Figure 3.2: Tidd and Bessant's (2009) simple model of the innovation process.**




Source: Tidd, J. and Bessant, J. (2009) *Managing Innovation: Integration Technological, Market and Organizational Change* Sussex, England, Wiley p. 55.

First, learning and knowledge processes are interrelated to influence innovation. Theorising knowledge processes as knowledge brokering roles, Hargadon (2002) argued that individuals can have different knowledge brokering roles and learning intentions that affect their actions during accessing, bridging, linking and building processes. Differences in knowledge brokering roles and learning intentions are due to influences from the wider social context that individuals are embedded in. As reviewed in the previous section, wider context can include various organisations and institutions.

Second, interactive models recognise that learning processes for innovation can be done for different reasons. Hargadon (2002) argued that individuals often learn with an eye towards innovation in very different situations. In some instances, individuals learn in order to be recognised for their expertise in the context where their knowledge is applied. In contrast, individuals sometimes learn in order to understand what problems are encountered in other domains and how they are addressed in order to work competently with others.

Differences in learning intentions for innovation were also identified by Van de Ven and Polley (1992) in their five-year longitudinal study of a biomedical device commercialisation. In situations where innovation requirements were clear, trial-and-error was a sufficient learning process for improving existing knowledge. In contrast, situations where innovation required indeterminate outcomes, trial-and-error was insufficient because the expected outcomes could not be assured.

Third, innovation increasingly occurs across firms' boundaries requiring internal and external learning and knowledge processes. Emphasis on internal and external interaction for innovation highlights the importance of boundary spanning processes. Allen's (1977) case study analysis of technical projects involving engineers and scientists is one of the seminal studies in this area. Analysing the boundary spanning processes performed by individuals, Allen (1977) demonstrated the importance of individuals action for the firms' innovation. Furthermore, in describing the details of individuals attending conferences and seminars, networking with external contacts, reading disciplinary articles and the like Allen's (1977) study underlines the importance of everyday activities for innovation.

Powell, Koput & Smith-Doerr's (1996) study of learning and R&D-based innovation in the Boston biotechnology region illustrated the increasing role of external learning processes for innovation. From the early stages of the biotechnology industry's evolution, it was clear that the full range of skills required to commercialise molecular biological ideas could not be achieved by single organisations. As a result of this, biotechnology firms entered into various interorganisational arrangements to fill gaps in their internal capabilities that were necessary to firms' continued innovation (Powell & Brantley, 1992).

In comparing the number and quality of innovations made by biotechnology firms to those of pharmaceutical companies, Powell et al (1996) found that biotechnology firms

performed significantly better than their counterparts. They theorised the networks that biotechnology firms created through their different organisational arrangements, such joint ventures, research agreements, licensing and the like, provided biotechnology firms with preferential access to external knowledge resources and innovation opportunities, which subsequently led to improved organisational performance.

Baum, Calabrase & Silvermann's (2000) study of Canadian start-up biotechnology firms drew similar conclusions to Powell et al (1996). Using a database of the alliance partnerships of 142 biotechnology start-ups over a six-year period, Baum et al (2000) found statistical support for hypotheses that newly establishing biotechnology firms who founded alliance partnerships and configured them to provide access to more diverse expertise exhibited stronger organisational performance than those who did not enter into alliances. Drawing upon Powell et al's (1996) 'network as locus of innovation' theory, Baum et al (2000) argued that alliance arrangements provide external knowledge that enables biotechnology firms' continued innovation.

The fourth theme regards increasing recognition of the role of individuals in firms' innovation. Hargadon (2002) argued that the focus on the role of individuals in innovation seeks to understand "how individuals in organizations construct innovations from pieces of the very landscape those innovations ultimately reshape" (Hargadon, 2002 p. 43).

Johannessen and Aasen (2007) made a similar point arguing that individuals need to be central in explanations of innovation because innovation occurs through large numbers of local events and interactions of everyday life in organisations.

Given the increasing recognition of the role of individuals in firms' innovation, it is worthwhile to concentrate on activities where individuals are known to take action. Search and selection are sub-processes of innovation where individuals' roles have been previously explored. It is useful to review what the existing literature says about the role of individuals' action for firms' search and selection processes and identify what is known about learning-knowledge-innovation relationship.

### 3.4.2.1 Search processes

Search process can be defined as scanning the internal and external environment for a wide range of signals and interpreting them for relevance to the firm (J. Tidd, Bessant, & Pavitt, 2005). In order to pick up signals firms need individuals to thoroughly scan the opportunity space to generate a requisite variety of opportunities (Van de Ven, 1986). A number of activities used in biotechnology search processes can be identified in previous empirical studies. These include individuals using firms' relationships with universities, venture capitalists, and, manufacturing and marketing firms. As well as, these individuals tend to use personal ties with inventors, public scientists, and other entrepreneurial firms too.

Firms cluster near universities to benefit from new technology opportunities. Geographic proximity to public scientists offers greater opportunities for individuals to hear about new opportunities through informal communication channels. Given that universities license out their discoveries, scanning the environment for signals of upcoming opportunities before competitors is advantageous (Bresnahan, et al., 2001; Chiaroni & Chiesa, 2006; Powell, et al., 2005).

Planned and unplanned face-to-face communication with inventors is reported as an important search method. Given new technologies that come from universities as proofs of concept only and require considerable development to become commercialised (Jensen & Thursby, 2001), face-to-face communication provides a means to learn about the potential of such concepts. The value of face-to-face communication is also important when the knowledge requirements around proofs of concepts are considered.

Knowledge required to efficiently advance early-stage science-driven products often remains latent because inventors cannot articulate everything that they know and have little incentive to codify the knowledge that can be captured (Agrawal, 2006). In his study of technology licenses from MIT's Mechanical Engineering and Engineering and Computer Sciences departments, Agrawal (2006) found firms whose employees access inventors' latent knowledge regarding licensed technology by 100 hours gained insights into inventors' intermediate knowledge and intuition building. Searching out latent knowledge informed ongoing development and increased the likelihood of commercial success by 23%.

Informal communication with public scientists provides a third search method. Given their co-location to public science organisations, biotechnology firms can search out the latent and tacit knowledge of their public science counterparts to find solutions to their problems. By using universities' research contracting and consulting services, biotechnology firms can search out knowledge without the ongoing costs of an increased labour force. (Bresnahan, et al., 2001; Chiaroni & Chiesa, 2006; Myint, Vyakarnam, & New, 2005; Powell, et al., 1996; Saxenian, 1994)

Activities related to new entrepreneurial start-ups and spin-offs of other biotechnology firms act as knowledge search opportunities in a different opportunity space. Job mobility is common due to high failure rates of biotechnology firms. Individuals counter this by maintaining peripheral involvement in multiple firms through consultancy, directorships, and, concurrent membership on senior management teams (Casper, 2007). As well as individual career management, these portfolios of activities provide opportunities for individuals to scout new start-ups for ideas of interest (Chesbrough, 2003) and develop new personal ties to other experts that they can call on in the future (Myint, et al., 2005; Saxenian, 1994).

Given the development requirements of science-based products are often beyond the research expertise of most biotechnology firms (Pisano, 1991), search processes often involve scanning the external knowledge of other organisations in the innovation system. These include venture capital firms, specialised business services and manufacturing, and marketing companies that provide downstream technological capabilities which are necessary to biotechnology commercialisation (Baptista, 1998). Through planned and unplanned meetings individuals can scan for opportunities regarding future investments (Powell, et al., 2002), interorganisational collaboration (Dorfman, 1983), and, solutions to for knowledge-gap problems.

### 3.4.2.2 Selection processes

Selection processes are concerned with choosing what opportunities firms' will pursue from those identified through search processes. According to Tidd et al (2005) selection processes are complex because of three factors. First, what possible opportunities identified

during search process might offer the firm. This infers that firms have an understanding of what is happening in wider technological and competitive markets. The second consideration concerns how the firm's existing knowledge base might integrate new opportunities. In order to assess integration a certain level of knowledge is required about the knowledge base of these opportunities. When firms' internal technical capabilities are weak there is little choice but to acquire external knowledge, whereas firms with strong in-house capabilities can often favour internal development of related technologies (Joe Tidd & Trewhella, 1997). Third, how the firm's overall business can be enhanced through new opportunities influences selection decisions. These factors "are as much about the management of the learning process within the firm as about investments or acquisitions" (J. Tidd, et al., 2005 p. 363).

Given the increasing external orientation of innovation, it is useful to survey the strategic alliance literature on selection processes. According to Geringer (1991) selection processes consider task and partner-related dimensions. Task dimensions refer to operational skills and resources offered, whereas partner-related dimensions refer to the efficiency and effectiveness of partners' cooperation. The relative importance of task and partner dimensions is determined by. Therefore, firms' evaluate opportunities by assessing the complementary skills on offer, the likelihood that a cooperative culture can exist between the firms, the compatibility of the firms' goals and the commensurate levels of risk viz-a-viz rewards and prior experience are recognised as common criteria for partner selection decisions (Brouthers, Brouthers, & Wilkinson, 1995).

In addition to task and partner-related dimensions Gulati (1995) argued that firms' prior experience influence selection decisions. Demonstrating that repeated alliances reduce uncertainty, risk and opportunism, Gulati (1995) argued that when making selection decisions firms review prior experience with partners who can offer complementary knowledge. Given information asymmetry makes innovation selection decisions difficult (Blomqvist, Hurmelinna, & Seppänen, 2005), prior experience is importance because it provides a similarity that acts as a selection heuristic reducing risk associated with collaboration (Podolny, 1994). Determining trustworthiness is also necessary because the firm must establish that a potential partner's competence is sufficient (Nooteboom, Berger,

& Noorderhaven, 1997). However, trust judgements that are competence-based are difficult when they are made in a different area of expertise (Levin & Cross, 2004).

Hansen and Birkinshaw (2007) argued firms can perform selection processes poorly because of inadequate selection criteria and inadequate consideration of implementation pathways. Regarding selection criteria, when evaluating new ideas decision-making criteria can be too strict so most ideas are shut down. In contrast, decision-making criteria can be so loose that too many projects are selected, which do not support the firm's strategy. Regarding implementation pathways, lack of consideration is given to assessing how ideas can be developed in viable products or services. The authors concluded that selection processes can be enhanced when individuals' decision-making is informed by an 'end-to-end' view of firms' innovation efforts, that considering broader consequences of selection decisions.

With regards to the importance of individuals' actions for selection processes, Van de Ven (1986 p. 140-145) argued individuals' experience influences them because selection decisions are "always conditioned by the range of past experiences and current situations to which individuals have been exposed". Due to prior experience individuals' are biased towards selection of opportunities that involve parties that are known and trustworthy.

## 3.5 Summary of the chapter

In this chapter I set out to survey literature on innovation as an important topic that informs the research problem, when innovation requires expertise from different knowledge domains, how do firms learn when there are few experts to learn from? Focussing on innovation as a process, my review concentrated of learning and knowledge as important organisational determinants of innovation (J Tidd, 2001). Moreover, my aim was to establish key innovation theories and principles that 1) inform the development of research questions that attend to the research problem of gaining expertise for innovation, and, 2) guide the development of an adequate research model to address those questions.

Recognising innovation as a multidisciplinary topic that has amassed a substantial literature in its thirty-year history (Fagerberg, 2005), my broad reading revealed three

theoretical perspectives contributing several important theories that informed the research problem

In regards to question 1, the three perspectives show that innovation is conceptualised in a range of ways providing different explanations about the purpose of innovation. In regards to question 2, learning and knowledge are crucial to innovation and they occur at different levels and through different processes. These are summarised in Figure 3.3. Despite the proliferation of theories of innovation some important issues remain.

The first gap in the literature concerns how firms organise their innovation in emerging regions and industrial clusters. Regional innovation systems and industrial cluster scholars argue that geographic proximity provides conditions for effective learning and knowledge processes. According to cluster life-cycle theory the characteristics of clusters vary across the cluster life-stage due to number of firms, number of employees and nature of common knowledge (Menzel & Fornahl, 2010). This raises an important question regarding how firms in emerging clusters organise their innovation when there are few firms with few employees to learn from and there is knowledge heterogeneity among them.

The second gap in the literature concerns the role of individual action in the innovation process. According to the relational view, fields of knowledge are divided by relational boundaries in the form of different behavioural rules, belief systems and ways of knowing (Amin & Roberts, 2008). Individuals' access to a field of practice is influenced by their ability to act in ways that are acceptable to that field. Unlike institutional and geographic explanations of learning and knowledge processes at the more macro-level of disciplines, sectors, nations and regions, relational explanations concentrate on the role of individuals. Furthermore, it is unclear how relations might interact with institutions and geography to influence innovation.

**Figure 3.3 Summary of perspectives on innovation**

| | Evolutionary Growth and Technology Management | Systems of Innovation | Processes of innovation |
|---|---|---|---|
| How innovation is conceptualised | Firm specific technologies in wider technological regimes. Technology is informed by, and influences wider technological regimes. | Evolutionary growth and interactive learning among organisations and institutions. | Complex interactions involving search and selection processes that occur within and beyond firms' boundaries. |
| The relationship between learning, knowledge and innovation | Learning generates knowledge in the form of firm-specific technology that drives firms' innovation. | Knowledge is the central feature of a modern society. Learning is socially constructive and interactive. Innovation is produced through interactions at all levels of the innovation system. | Learning and knowledge are interrelated processes to influence individuals' actions and firms' innovation. |
| Level(s) of analysis used | Firms within industries | Disciplines, sectors, nations, regions and clusters | Firms and Individuals |
| Nature of the explanation | Evolutionary | Dynamic | Processual |

# 4. RESEARCH QUESTIONS AND RESEARCH MODEL

This chapter introduces and outlines two research questions and the research model. First, the research questions are drawn from problems faced by biotechnology firms in Auckland, New Zealand and gaps in the existing literature. Next, theoretical perspectives on organisational learning, organisational knowledge, innovation theories and management perspectives are integrated to produce a research model that is used to address the research questions. The research model is operationalised in four intellectually related research studies that are reported as independent research papers. I conclude the chapter by summarising how the four studies address the research questions.

Practice-based view scholars have clearly outlined the need to understand learning and knowing as a cognitive and social process that is situated in social worlds (Gherardi, et al., 1998; Lave & Wenger, 1991). What is less clear from the literature is how individuals navigate different social worlds when they do not aspire to become experts in those social worlds.

Innovation scholars have shown that operating across disciplinary worlds is increasingly important for firms' innovation (Hargadon, 2002; J Tidd, 2001). Nevertheless, at the same time specialisation makes it increasingly difficult for individuals to be experts in multiple specialisations. At the same time, expertise is located across organisations and geographies (Pisano, 2006b; Powell & Brantley, 1992). Therefore, firms face the challenge of accessing knowledge (R. Grant & Baden-Fuller, 2004).

Industrial clusters have been proposed as a means of encouraging knowledge processes to over firms' knowledge access challenge. However, for firms in emerging industrial clusters there are limited opportunities for localised learning and knowledge sharing (Menzel & Fornahl, 2010). Instead, firms must rely on communication pipelines that connect them of extra-local networks that can be used to search out and select partners for knowledge access (Bathelt, Malmberg, & Maskell, 2004).

While attention has been paid to firms' learning and knowledge for innovation, my literature reviews in Chapters 2 and 3 demonstrate there has been little attention given to the role of individuals in the innovation process. Given it is individuals who search and select partners for knowledge access, this is a research gap that requires closer attention, especially in the context of emerging industrial clusters where there are a limited number of individuals that firms can use. Furthermore, understanding the practices of individuals for firm's innovation is important to understanding individual navigate the different social worlds in order to access knowledge that is necessary to the firms' innovation.

## 4.1 Research questions

As described in chapter one, the research problem for biotechnology firms in Auckland, New Zealand is, *when innovation requires expertise from different knowledge domains, how do firms learn when there are few experts to learn from?*

Given that it is individuals who learn (not firms), and, recognising that industrial cluster life-stage, interactive learning in the innovation system and knowledge-based development are likely to influence firms' learning and knowledge processes as they access expertise for innovation,

1. *What obstacles do biotechnology firms in emerging industrial clusters face to accessing expertise for innovation?*

Motivated by findings to the first research question, process of innovation models, and, the practice-based view of learning and knowing,

2. *How are individuals' search and selection practices for firms' innovation influenced by geographic and relational location?*

## 4.2 Search and selection processes

Recognising the increasing openness of innovation, search and selection are critical processes for gaining expertise. Search can be defined as a firm-level process of scanning the internal and external environment for a wide range of signals and interpreting them for relevance to the firm (J. Tidd, et al., 2005). Selection can be defined as a firm-level process of choosing what opportunities the firm will pursue (Van de Ven, 1986). Search and selection are critical processes for biotechnology firms' innovation in the Auckland cluster. In order to address research question one regarding obstacles to accessing expertise for innovation it is necessary to identify firms' search and selection processes.

According to Hargadon (2002) individuals' knowledge brokering roles and learning intentions are at the heart of any attempt to understand how firms' innovation is shaped. Johannessen and Aasen (2007) made a similar point arguing that individuals need to be central in explanation of innovations because innovation occurs through large numbers of local events and interactions of everyday life in organisations. Therefore, in order to address research question two regarding search and selection practices for firms' innovation it is necessary to explore individuals' practices.

Since development requirements of science-based products are often beyond the research expertise of most organisations (Pisano, 1991; Powell & Brantley, 1992), biotechnology firms need individuals to thoroughly search the opportunity space to generate requisite variety of opportunities (Van de Ven, 1986). Individuals can use a range of activities to scan the environment for signals and interpret them. These activities include individuals using firms' relationships with universities, venture capitalists and manufacturing and marketing firms. Individuals use personal ties with inventors, public scientists, and other entrepreneurial firms also.

In regards to selection processes, individuals can use firms' prior experience (Gulati, 1995; Podolny, 1994), firms' selection criteria (MT Hansen & Birkinshaw, 2007) and individuals' person experience (Van de Ven, 1986). Personal experience is important because individuals' selection decisions are "always conditioned by the range of past experiences and current situations to which individuals have been exposed" (Van de Ven, 1986 p. 140-145), which biases them towards selection of opportunities that involve knowledge and parties that are known and trustworthy.

## 4.3 Accessing expertise.

Expertise refers to the specialized skills and knowledge that individuals bring to the task. Expertise is situated in the knowledge domains or cultural fields where skills and knowledge are used (Bourdieu, 2005; Brown & Duguid, 1991). In this research, the expertise under investigation relates to scientific and commercial expertise required for innovation in biotechnology firms.

- Scientific expertise resides in a number of cultural fields, including genetics, microbiology, animal cell culture, molecular biology, bio-chemistry, embryology, cell biology, chemical engineering, bio-process engineering, bio-informatics and bio-robotics.
- Commercial expertise resides in investment, pharmaceutical, regulatory, research hospital, manufacturing control and monitoring, and, marketing cultural fields.

Knowledge access refers to the firm-level process of applying knowledge from a partner's knowledge domain to the firm's products with an intention of maintaining the distinctive knowledge bases of both firms (R. Grant & Baden-Fuller, 2004). Firms use knowledge access to gain expertise required for innovation because the costs associated with developing that expertise can be uneconomic due to the time taken to develop expertise and the high risk that knowledge learned will be made redundant by new developments (F. Murray, 2001).

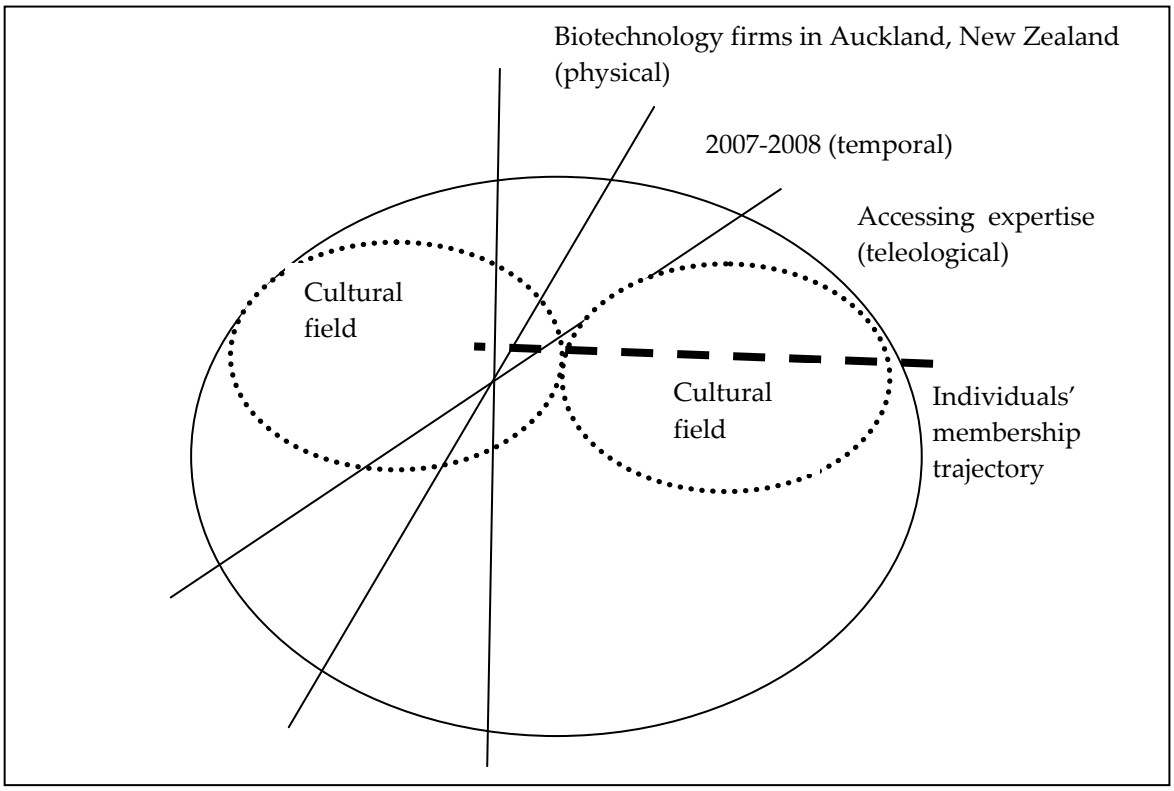
### 4.3.1 Practice-based view of accessing expertise

While firms have knowledge access processes, individuals search out and select expertise for firms' innovation. To address research question two, the practice-based view of learning and knowing is used to understand how "participating with requisite competence in the complex web of relationships among people and activities" (Gherardi, et al., 1998 p. 274) enables individuals to search out and select expertise for firms' innovation.

Individuals' practices can be understood as their 'doings and sayings' (T. Schatzki, 2002). Practices are performative, meaning that through performance they can be observed and understood. Moreover, practices are performed in sites that have physical, temporal and

teleological dimensions that influence where and when practices are performed and what they mean (See Figure 4.1).

**Figure 4.1 Sites of practices in the research**




In this study the physical dimension is biotechnology firms operating in Auckland, New Zealand, the temporal dimension is 2007-2008 when the data were collected, and the teleological dimension refers to search and selection practices for accessing expertise.

## 4.4 Influences on accessing expertise

There are a number of factors that are likely to influence firms' and individuals' practices for accessing expertise. These include cluster life-cycle stage, interactive learning, knowledge-based development, and social worlds.

### 4.4.1 Cluster life-cycle stage

To explain clustering processes, Menzel and Fornahl (2010) theorised a four stage cluster life-cycle theory. Each cluster stage is characterised by differences in the number of firms, number of employees and the nature of the localised knowledge base. Given that each cluster life stage presents different characteristics it can be assumed that innovation activities will differ across the stages. Clusters in the emerging stage are characterised by:

- Few firms with a lasting vision for a new local technology path,
- Favourable local scientific and political conditions to support cluster growth to a critical mass,
- Small skilled labour market due to few workers having been employed, and,
- Heterogeneity of technology

Given the Auckland biotechnology cluster is an emerging cluster, it can be assumed these characteristics are likely to influence how firms and individuals access expertise.

### 4.4.2 Interactive learning in the innovation system

Interactive learning refers to the practical skills established through learning by doing, new insights produced by R&D, and capabilities acquired through formal education and training (B. Lundvall & Borras, 1997). In this research industry, government and university stakeholders had recognised the need to expand existing science and commercialisation capabilities and introduce additional expertise. In response to this a number of initiatives were launched, including a project to develop a Biotechnology Community of Practice that aimed to 1) make already locally available expertise more accessible, and 2) address gaps in local expertise (Kistler & Husted, 2005). Given these attempts to increase the direction and rate of learning in the New Zealand innovation system, interactive learning is likely to influence firms' and individuals' practices to access expertises for innovation.

### 4.4.3 Knowledge-based development

According to knowledge-based development scholars, government plays an important role in influencing the interactions between organisations who are involved with

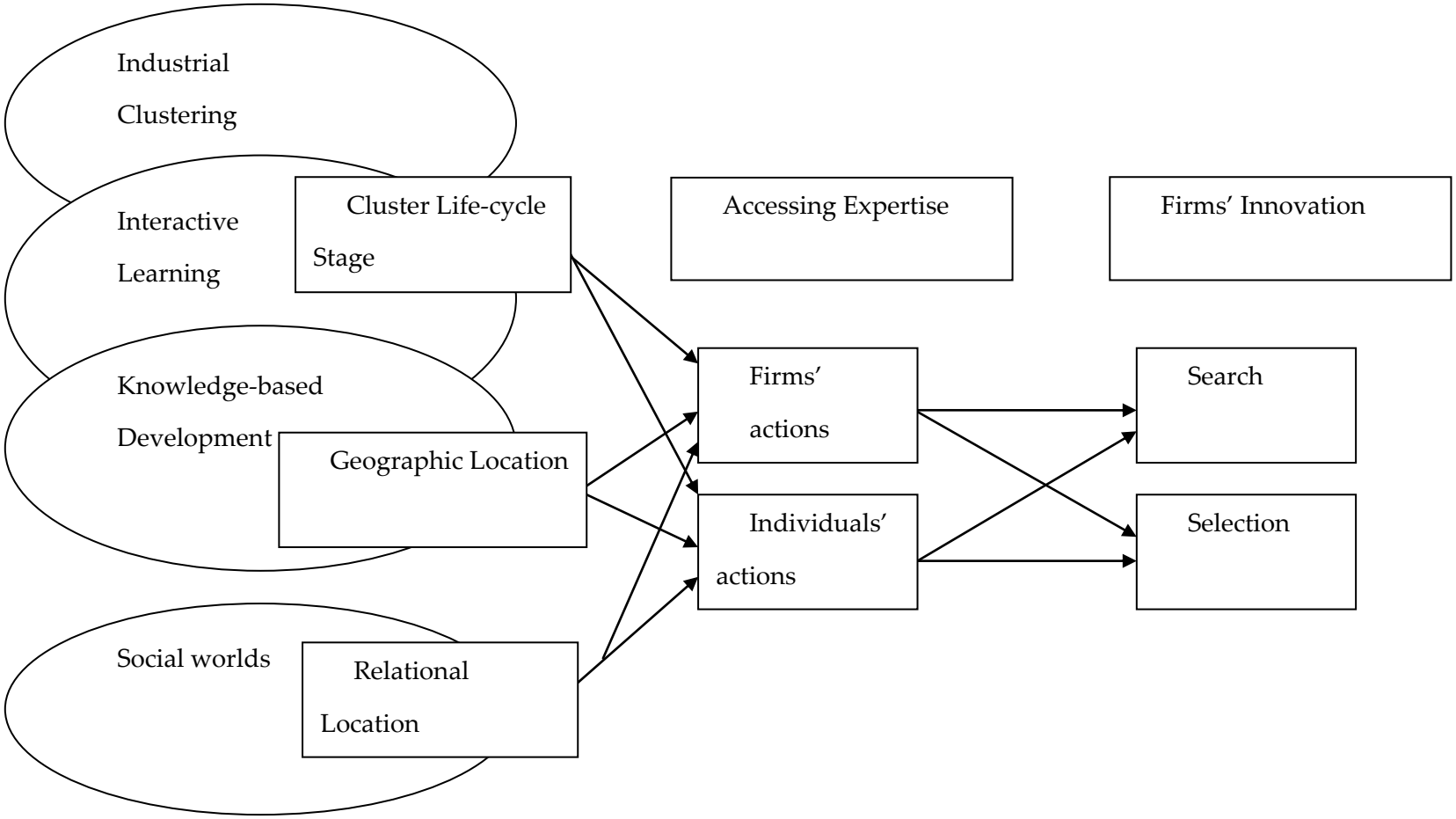
transforming global knowledge into local development (Carrillo, 2002; Knight, 1995). In this research the New Zealand government is known to have taken a number of actions to facilitate the development of a biotechnology industry in Auckland. Given that governments take strategic action to facilitate and co-ordinate innovation systems by implementing public policy through their agencies (Mansell, 2002), it can be assumed that innovation policy is likely to influence firms' knowledge processes.

### 4.4.4 Social worlds

The notion of social worlds refers to the social organisation of participants around a common set of images, processes, interactions and relationships (D. R. Unruh, 1980). Innovation in biotechnology requires expertise from many cultural fields. In order to access expertise individuals need to be able to participate in different cultural fields. However, participation requires individuals to understand the field's norms, values and rules of thought and action that are accepted in the field (Coenen, et al., 2004). In some situations individuals need to be expert in the field, but in other situations being an adequate performer is sufficient. Unruh's (1979) social worlds typology offers a framework for understanding different forms of participation in cultural fields that are likely to influence individuals' search and selection practices for innovation.

In summary, based on cluster life-cycle stage, interactive learning in the innovation system, knowledge-based development, and social worlds literatures, the following research model proposes that cluster life-stage, geographic location and relational location are likely to influence how firms' and individuals' access expertise for firms' search and selection processes for innovation.

## 4.5 Research Model



## 4.6 Summary of the studies and the chapter

The first research question, *What obstacles do biotechnology firms in emerging industrial clusters face to accessing expertise for innovation?*, is addressed in two studies that follow on from the research methods chapter. The first study uses a system of innovation perspective that recognises disciplines in the form of norms regarding roles in the innovation system and the national innovation system in the form of New Zealand's knowledge-based development. These perspectives are used to examine organisational actors' participation in public debates about biotechnology (Chapter 6). The second study examines how interactive learning in the innovation system and knowledge-based development influence firms' practices in the form of firms' communication channel use (Chapter 7). These studies contribute to understanding how the contextual factors in an emerging industrial cluster influence firms' knowledge processes for innovation. In particular, these studies highlight how different levels of the innovation system interact and how firms experience those interactions.

The second research question, *How are individuals' search and selection practices for firms' innovation influenced by geographic and relational location?*, is addressed in two studies using a practice-based view that recognises the situated nature of learning and knowing. One study focuses on individuals' search practices for innovation and explores how these are influenced by firms' geographic and relational location and emergent cluster life-stage and the nature of individual experience (Chapter 8). The other study concentrates on individuals' selection practices for innovation and explores when and why varying forms of geographic and relational location influence them (Chapter 9). These studies draw to the attention the importance of individuals' practices for firms' innovation. Furthermore, they demonstrate how individuals' practices are affected by geographic and relational influences.

In summary, this chapter introduced and outlined two research questions and the research model used for this research. Theoretical perspectives on processes of innovation, practice-based view of learning and knowing, cluster life-cycle stage, interactive learning in the innovation system, knowledge-based development, and, social worlds were integrated to produce a research model that is used to address the research questions. Finally, the four studies that operationalise the research model were summarised.

# 5 METHODS

This chapter outlines and explains the research approach, data collection methods and analysis techniques used in the research. I begin by summarising background to the project that informed decisions regarding the research approach taken in the four studies. Next, I outline and explain the different data collection methods used over the course of the research. I outline and explain the analysis techniques used for each of the four studies and then explain how quality of the research can be judged.

## 5.1 Background to the research

In mid-2006 when I began initial preparation for the PhD research, an industry-university project had successfully secured financial support from government for a three-year project to develop a Biotechnology Community of Practice. Informed by Wenger et al's (2002) theory that communities of practice facilitate learning and innovation in organisations, the leaders of the Biotechnology Community of Practice project recognised that a community of practice might address a number of constraints to industry growth. The point of departure in my research was to focus on firms' learning and knowing processes in the innovation system. This motivated the research problem when innovation requires expertise from different knowledge domains, how do firms learn when there are few experts to learn from?

## 5.2 The research process

Given that firms' learning and knowing processes can be influenced by wider systems of innovation (B Lundvall, 1992), and that innovation systems are the product of historical

organisations and institutions (Edquist, 1997), it was necessary for me to understand the history of biotechnology in New Zealand's innovation system and to explore firms' current experiences. Throughout the research my understanding of the practice-based view of learning and knowing for innovation and of biotechnology changed, so the results of the initial studies influenced my decisions regarding the choice and direction of subsequent studies.

Due to the exploratory and evolving approach it can be difficult to outline a linear research process that encapsulates the various data collection and analyses I undertook over the three-year period. Instead, it can be more helpful to consider the overall research design as a series of studies. The studies stand independently in their own right, but each is informed by decisions regarding previous ones. Most importantly, when considered together they address the research questions posed.

*Research Question 1: What obstacles do biotechnology firms in emerging industrial clusters face to accessing expertise for innovation?*

The main finding from preliminary investigations that addressed Research Question 1, which are reported in study one and study two, was firms faced considerable challenges to organising human clinical trials. Figure 5.1 provides an overview of the studies. Clinical trials are crucial in the research and development of biotechnology. Broken into a number of phases, clinical trials typically require "manufacturing know-how, in vitro and in vivo toxicology testing, regulatory filings with the US Food and Drug Administration, and mobilising physician investigators to enrol patients into early-stage clinical studies" (Ahn & Meeks, 2008 p. 22). Furthermore, links between biotechnology firms and organisations providing these activities represent critical bridges in the drug development process.

Biotechnology firms make strategic decisions regarding what expertise they develop and what expertise they access elsewhere (R. Grant & Baden-Fuller, 2004). In the emerging Auckland biotechnology cluster, this often meant firms accessing expertise from firms in other countries. Firms continued to work with public science organisations whose relational location in terms of goals, value systems, and communication and compensation systems are distant from theirs, but whose geographic location was proximate. At the same time,

biotechnology firms' began working with a new set of organisations involved in human trials, such as contract research organisations.

On face value the relational location of these new organisations was often closer to commercial firms in terms of common goals, communication and compensation systems. However, they often differed in terms of their value systems, norms and ways of knowing. Furthermore, the geographic location between biotechnology firms in Auckland and their new partners varied from proximate to distant. Therefore, strategic decisions about human clinical trials presented a number of organising issues regarding firms' learning and knowing processes.

*Research Question 2: How are individuals' search and selection practices for firms' innovation influenced by geographic and relational location?*

For studies three and four that address Research Question 2, I chose the case study approach to explore how individuals' learning and knowing processes were influenced by the emergent cluster life-stage, geographic location and relational location. Figure 5.1 provides an overview of the studies. According to Kanter (1988) the case study approach is useful for exploration and description of interorganisational innovation. Furthermore, the case study is a common approach used in practice-based studies (For example, Handley, Clark, Fincham, & Sturdy, 2007; Nicolini, 2007; Orlikowski, 2002; Tagliaventi & Mattarelli, 2006) .

Having chosen the case study approach my next step was to sample biotechnology firms whose employees' roles involved accessing knowledge for innovation. My criterion for sampling was human therapeutic firms that had experience of the Phase II human clinical trials. This theoretically sampling (Eisenhardt, 1989) was informed by my preliminary findings that Phase II human clinical trials was where the emergent cluster life-stage and varying locations of innovation were likely to influence learning and knowing. Furthermore, by focussing on human therapeutics firms as sub-set of biotechnology firms I avoided comparing firms' with different clinical trials requirements. For example, medical device firms have different regulatory requirements and collaborate with different types of organisations. Based on this criterion I identified seven potential participant firms.

CEOs or General Managers of the seven firms were invited to participate in my research by email and follow up telephone calls. Three firms agreed to participate, two firms declined, one firm did not reply to emails or telephone messages and one firm asked me to approach them in quarter four of 2008 when they might be able to accommodate my invitation. Unfortunately, that firm went into receivership before I could approach them. The three firms that agreed to participate were typical cases (Patton, 1980, Yin, 1994) because the firms had made strategic decisions about their research and development activities and were working through the associated organising issues.

**Figure 5.1 Overview of the studies**

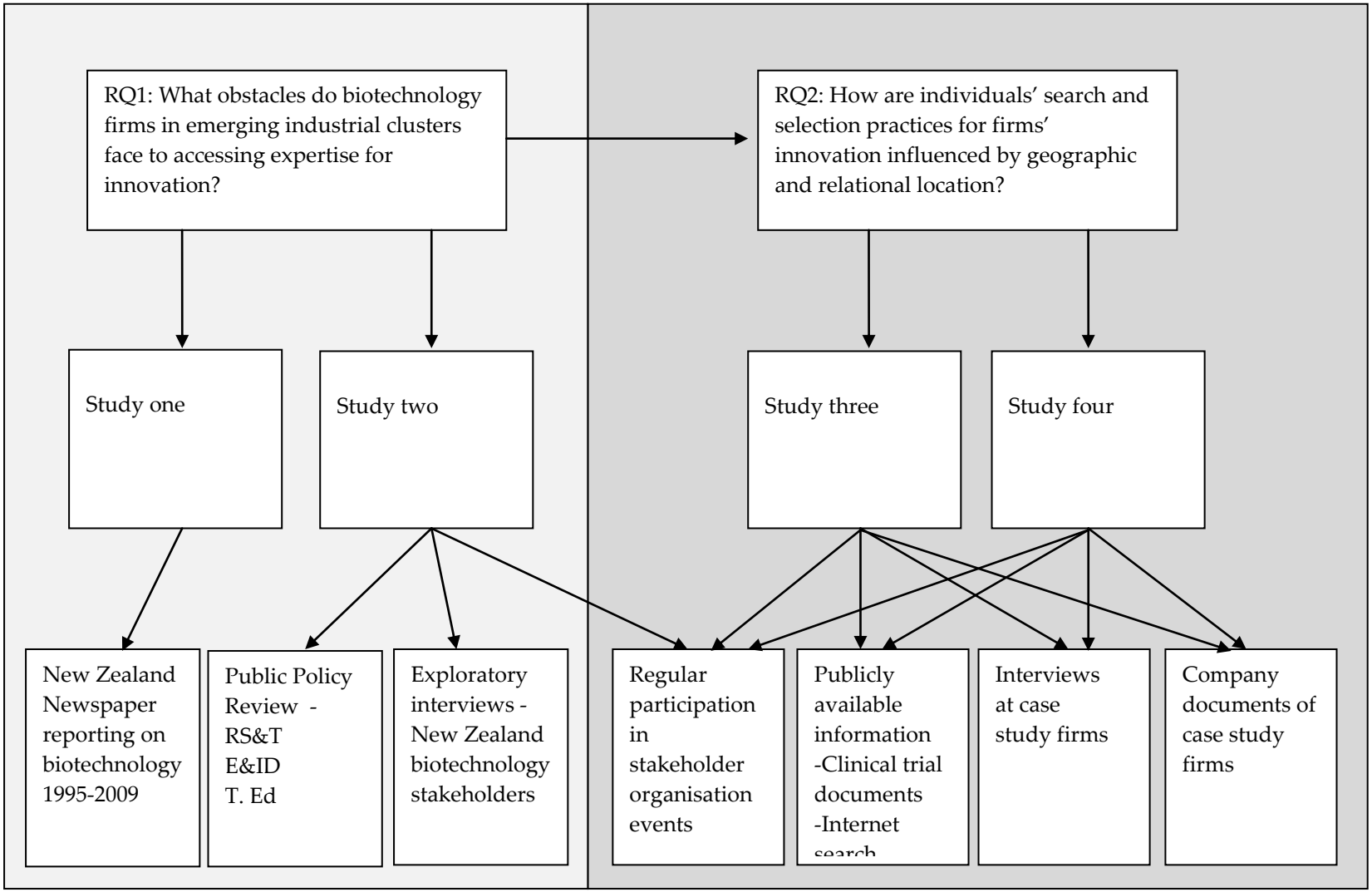
| | Study one | Study two | Study three | Study four |
|---|---|---|---|---|
| Research question addressed | RQ 1: What obstacles do biotechnology firms in emerging industrial clusters face to accessing expertise for innovation? | | RQ2: How are individuals' search and selection practices for firms' innovation influenced by geographic and relational location? | |
| When data collection occurred | January 2007 - January 2010 | March 2007 - June 2008 | August 2008 – April 2009 | August 2008 – April 2009 |
| Unit of Analysis | Newspaper article | Firms' communication channel use | Individuals' practices for the firm | Individuals' practices for the firm |
| Status of the study | Published – International Journal of Knowledge-Based Development (2010) | Working paper | Accepted for publication – International Journal of Entrepreneurship and Innovation Management (forthcoming) | Accepted for conference - ANZAM (2010) |

## 5.3 Data collection

To address the research questions seven sources of data were collected. According to Handley et al (2007) this is advantageous as a single data collection method is insufficient and potentially misleading if used in isolation to understand situated learning and knowing. Similarly Malerba (2002) argued that investigation of any innovation system needs to be flexible enough to consider different levels of analysis. While no method is perfect, using a number of techniques can provide a comprehensive view (Chang & Chen, 2004). In this

section, I outline and explain each of the seven sources and my methods for collecting the data. I conclude the section with a note regarding other data sources that I intended to use but for pragmatic reasons had to abandon. How the different sources of data informed each of the studies is illustrated in Figure 5.2.

**Figure 5.2: Research process overview**



### 5.3.1 Newspapers articles

One way to understand how biotechnology evolved in New Zealand was to examine reporting of it in the media. Following the approach of Bissell (2000) and Holdford and Yom (2003), I searched a daily national newspaper, *The Dominion Post*, via the ANZ Reference Centre database for articles associated with biotechnology. *The Dominion Post* was selected because among the three daily newspapers published in New Zealand it is best recognized for covering national, political and business news. In contrast, the *NZ Herald* concentrates on business news rather than politics and *The Press* focuses in local and regional news of special interest groups (Rupar, 2006). While analysis of all three sources was likely to identify differences in the reporting patterns among them, my aim was to explore how biotechnology evolved in New Zealand, rather than a comparative media analysis.

In order to understand how biotechnology evolved it was necessary to explore media reporting over a period of time. Initially I searched the period January 1995 to December 2006, as public debates were known to have occurred during this period. Then, each year I added annual data to cover 2007-2009. Overall, this provided a data set covering a period of 15 years. Having a data set of a number of years was important because it provided an index of the intensity of reporting and a measure of changing salience over time (Bauer & Gaskell, 2002).

Using Bauer and Gaskell's (2002) sampling method, the search string "biotech* or genes or genet* or genom* or DNA or clon* or ivf or intro or vitro or "test tube bab*" or "stem cell" or "clinical trial" or bio or bio waste or "medical device" or "medical imaging" or "medical diagnostic" or biochem* or "functional foods" or nano*" identified 4095 articles. From the total number of articles a 10% stratified sample (416 articles) was selected. This was achieved by listing every article for each calendar year in chronological order of publication and then selecting every seventh article until I had 10% of that year's total articles. To ensure that articles covered the whole period (Altheide, 1996) this was done for all 15 calendar years to provide the sample.

However, early on I noted that a reasonable proportion of articles in the stratified sample were not about biotechnology per se. Thus, to understand patterns of biotechnology

reporting I had to clean the data further. Following the method used by Horst (2003) I categorised articles in the stratified sample as having a biotechnology focus when the biotechnology topic was articulated in a full paragraph (i.e. more than one sentence). Articles that did not fulfil this criterion were disregarded during the cleaning process. This left me with a final sample of 152 biotechnology-focused articles for systematic analysis.

### 5.3.2 Public policies

From the Systems of Innovation and Knowledge Based Development perspectives, government is an important actor influencing innovation. Public policies related to innovation provide a means of understanding New Zealand government's goals and ambitions. In 2002, New Zealand's government launched a Growth and Innovation Framework (GIF) that outlined the vision for the country's economic and social growth. The GIF identified Research, Science and Technology (RS&T), Industrial and Economic Development (E&ED), and Tertiary Education (TE) as central agencies for developing policies to facilitate innovation.

All policies, the Ministries' press releases outlining each policy's purpose, and reviews of the policies are publicly available from online archives. To sketch out the range of policy instruments implemented, the documents were collected. Fortunately, archiving of government documents was very systematic through the 2000s, so documents were easily accessed. Unfortunately, this was not the case for documents from the 1990s for two reasons.

Prior to the GIF, no formal policy was concerned with innovation for economic and social growth. RS&T policy was mainly oriented towards public funding of public science for basic and applied science, rather than for innovation and economic growth. Similarly, I&ED and TE policies were oriented towards the industrial society through stabilising economic conditions and supporting traditional higher education aims of disciplinary research and teaching. In addition, there being fewer policies and documents were harder to identify because gaining electronic copies relied on them being added retrospectively to the government's online archive. Nonetheless, policies from the 1990s were commonly referred to in policies from the 2000s, which meant they could be identified. In addition, the government's online archive of policies from the 1990s was partly backdated, so electronic

copies of some policies were collected. When these were not available, I requested hard copies through the National Library Service.

### 5.3.3 Exploratory interviews with industry stakeholders

To understand what innovation issues New Zealand biotechnology firms were experiencing I undertook a series of semi-structured interviews in collaboration with another PhD candidate. We developed an interview guide that reflected our related interest in biotechnology firms operating in New Zealand and served our individual research.

Liaising with well-known members of the NZBio-Auckland stakeholder organisation, we secured interviews with CEOs or General Managers from nine biotechnology firms. Two of the firms were from Otago, New Zealand and the rest were from Auckland, New Zealand. Interviews with the participants from Otago were completed by telephone and interviews with the Auckland participants were completed face-to-face at the firms' premises. For the first two interviews, my colleague and I attended the interviews together, with one person interviewing and the other observing. This was to establish a common understanding about how the interview guide was used in situ. After that, we divided the interviews between us. My colleague completed four interviews (of which one was by telephone) and I completed three interviews (of which one was by telephone).

Interviews were undertaken between June and September 2007. Each interview took 45-minutes on average, although two interviews lasted more than 120-minutes. Interviews were recorded with participants' permission, although in two instances participants declined to be recorded. In these instances, the interviewer took notes during the interview and wrote a summary directly following. Interviews that were recorded were sent for transcription through a professional transcription service. When they were returned, my PhD colleague and I independently reviewed the transcription and added our memos. Then we compared our reviews and additional notes to provide commonly agreed documentation of the interviews.

### 5.3.4 Conversations at industry events

From February 2007, I participated as a member of NZBio-Auckland, a biotechnology stakeholder organisation. My membership was part of The University of Auckland's institutional membership. NZBio-Auckland facilitated regular events, including networking sessions, formal dinners with keynote speakers, workshops on issues identified by the membership, and an annual conference.

By regularly participating in these activities, I engaged in many conversations that informed my understanding of the research problem. I was also introduced to a number of individuals who later agreed to participate in my research. As well as keeping a log of the events I attended, I also kept summary notes about conversations that later informed my understanding of the research setting and decisions I took regarding the research questions.

Keynote speakers were a common feature of NZ-Bio Auckland's events. Four of the human therapeutics firms from the Auckland cluster spoke at 2007 events. During these speeches, I took summary notes that informed my understanding of the research problem. Later, once I had made the decision to concentrate on learning and knowing related to Phase II clinical trials, I used those notes to develop my understanding about the case study firms.

As well as attending industry events, I also co-authored a working paper about the evolution of the Human Therapeutics Special Interest Group (SIGHT), a sub-group of NZBio-Auckland. The working paper was co-authored with Geoff Whitcher, a founding member of the Auckland biotechnology stakeholder organisation that proceeded NZBio-Auckland, and Commercial Director at The University of Auckland Business School. The working paper was a descriptive case study about the evolution of the biotechnology eco-system in Auckland and was used by SIGHT and NZBio-Auckland to inform policy-makers of the Group's progress. To assist with construction of the case members of SIGHT provided written first-hand accounts about their experiences that we incorporated into the case. The first-hand accounts provided further insights into individual members' experiences and guided my understanding of the current situation.

### 5.3.5 Publicly available information – clinical trial records

Biotechnology firms who run human clinical trials submit their trial plans and results to a number of regulatory agencies, usually agencies in the local jurisdiction where the trial takes place and to The US' Federal Drug Agency (FDA). Acceptance of plans by the Federal Drug Administration (FDA) is necessary to firms' being able to sell their products in the future. Fortunately, all clinical trials submitted to the FDA are publicly accessible from the FDA's database.

Clinical trials records provide a number of items of information that were pertinent to this research. Each application identifies the applicant organisation and any co-applicants. The principal investigator is listed along with other individuals who are points-of-contact. The location of trial sites and the organisations running those trials are listed. Organisations financially underwriting the trial are identified as well. This information was very useful to identifying firms who were planning to run clinical trials and who has completed them. What firms collaborate with and where their partners are geographically located was established. This contributed to identifying potential firms for case analysis. It also assisted in refining my questioning of individuals at the case firms, which is outlined next.

### 5.3.6 Interviews at case study firms

At each case, firm individuals involved in various aspects of preparation and execution of the clinical trials were identified with assistance of the CEO or Operations Managers, and invited to participate in my research. The firms' small size saw most individuals involved in strategic and operational aspects of clinical trial work. Given that activities cannot be isolated from the goals and expectations of individuals who make decisions related to organisational development, small firms provide a unique and discrete location of activity where it is possible to examine the evolution of situated practices (Zhang, Macpherson, & Jones, 2006).

Liaising through the CEO or Operations Managers, 13 participants from the three firms agreed to participate in semi-structured interviews. Data collection from the interviews was concerned with identifying and exploring practices that individuals used to access knowledge in relation to human clinical trials for firms' innovation. The semi-structured

interview schedule was organised around themes identified in the literature. Themes included the nature of the interorganisational activities that individuals were involved in, their roles in clinical trials and the activities they used to search out and select partners. Each theme was pursued through open-ended questions that evolved during each interview in response to participants' replies.

Interviews were undertaken at the firms' premises between August 2008 and April 2009. Each interview took 60-minutes on average and was recorded with participants' permission. Following each interview the recording was sent for transcription through a professional transcription service.

### 5.3.6 Company information from case study firms

For each case firm, documents were obtained regarding the organisation of the firm. Specifically these were annual reports, interim information on clinical trials and organisational charts. From this information, I was able to ascertain firms' perceptions of their capabilities and their strategies regarding their research and development pipeline. These were important to understanding what learning and knowing firms sought to access.

### 5.3.7 Observations – an abandoned method

One traditional method used to study practice is ethnography. According to Handley et al (2007) observation and interview methods can be used to investigate how individuals observe practices in a community, and then imitate, experiment with, or adapt them in their performance of them. However using the observation method can be problematic for a number of reasons. First, revealing the meaning of activities still requires structural explanations through theoretical framing and deductive logic. Secondly, it can be difficult to determine what interactions to observe because all learning is practice according to Situated Learning Theory (Handley, Clark et al. 2007). Third, the observation method assumes that potential research participants agree to what can be an intense activity over an extended period. Fourth, it assumes the nature of work and interactions among people can be

observed. While I was able to address the first two issues, I was not able to address the third and fourth.

Regarding firms' consent for observation, I received very frank feedback from one CEO stating that the nature of their work was of such commercial sensitivity that consent for observation would not be given under any condition. This is understandable for a small firm working in an open-plan office where staff were discussing all aspects of the business on a daily basis. It was very impractical to accommodate a researcher observing practices related to clinical trials because it would be very disruptive to their work.

Regarding the nature of work and interactions among individuals, after three months negotiating with the seven potential firms that met my theoretical sampling requirements, I had no participants. It became apparent during discussion with two potential participants firms that the nature of the work meant staff were often working away from the office. This included work in laboratories and travel to clinical trial sites, which were secure access sites. At these small firms it was common for individual staff to be the only person in the office for days on end. This presented some logistical challenges to using a method that observes interactions between people.

This left me with three options; 1) wait until another firm began phase-II clinical trials work, but risk delaying the project for months; 2) change from studying human therapeutics firms to other biotechnology firms, which meant I would have to forego knowledge and relationships I had built up, and face risk of not securing participation of other firms; or, 3) modify my research design to remove observational data, and use alternate methods

Given the concerns with securing firms' participation, and time constraints around PhD completion, I made the decision to not use observation methods for data collection. The implication of this is that whilst the methods used cannot replace observational data, they were selected to provide credible and dependable data for analysis for the studies.

## 5.4 Data Analysis

Data collection and analysis happened in parallel with interpretation of the different data informing each other(Gibbs, 2002). Therefore, it is useful to outline the analysis procedures

used for each study, rather than the procedures used on each data source. In this section, I outline and explain the analysis procedures I used in each of the four studies.

**Study one**

To explore patterns of media reporting content analysis was used on a sample of newspaper articles from *The Dominion Post*. Content analysis involves the conversion of text into numerical variables for quantitative data analysis (Collis and Hussey, 2003). Content analysis was selected to identify patterns of media reporting because it enabled the exploration of a large number of newspaper articles over an extended period of time. Consideration of the institutional environment is not common in behavioural studies but it is required to understand how it influences organisations' roles in the innovation system. It also helps understand how innovations are generated, spread and used across markets, industries and societies (Kanter, 1988). By undertaking content analysis of media reporting the ways biotechnology were framed and actors' views were reported helped to understand the institutional environment.

**Study two**

An embedded case study of the human therapeutics firms in the Auckland biotechnology cluster was constructed from exploratory interviews, conversations at stakeholder events and the descriptive cases written for the SIGHT working paper. These were augmented with innovation-related public policies to explore how firms' knowledge processes were influenced by government attempts at affecting national and sectoral innovation systems. The data were analysed using a theory of cluster communication channels that explains firms' knowledge processes through face-to-face, buzz and pipelines (Bathelt, et al., 2004).

**Study three**

For studies three and four case studies of three biotechnology firms were created using interview data from the case firms, company documents, conversations at industry stakeholder events, and public information in the form of clinical trials documents. These were collated and analysed from a practice perspective. A practice-based view of learning and knowing provides a theoretical perspective for analysing the way work is accomplished

and how knowledge is created and used (Brown & Duguid, 2001). Furthermore, practices that are talked about, written down and observed provide a way of understanding how the context in which work is situated shapes innovation (S. Cook & Brown, 1999 p. 386f). This is necessary to understand why innovation cannot be simply copied and transposed onto other contexts but require adjustment for local factors.

To make sense of the data for study three, inductive pattern searching (Gibbs, 2002) was used to ascertain patterns of search practices within the emerging cluster. Inductive pattern searching can be enhanced through multiple readings of the data informed by literature (Eisenhardt, 1989). Multiple readings of the data were made to understand the influence of cluster life-stage, geographic location and relational location on search practices to access knowledge for innovation. Individuals' practices found in the case firms were compared with those reported in existing cluster literature and similarities and differences were explained using the practice-based view.

**Study four**

In study four, I combined theoretical reasoning with the three case studies to explain and illustrate four theoretically derived quadrants regarding geographic and relational influences on partner selection practices. Combining theoretical review and empirical cases was done because it can help to develop a more coherent and detailed set of hypothesis in further research (Brink & Mckelvey, 2010).

Broadly, there are two approaches to identifying partner selection. One approach is to categorise empirical data against existing frameworks. The other approach is to induce categories from the data (Miles & Huberman, 1994). For this study, I used the latter approach so that theory development of understudied phenomena of emerging cluster life-stage and relational location were guided by the data. Every partner selection activity that was reported by actors during the interviews and identified in the other data was categorised. The initial coding was then reviewed to ensure that each category represented a distinct partner selection activity. In total, 10 partner selection activities were identified in the data.

To make sense of the data, inductive pattern searching (Gibbs, 2002) was used to ascertain patterns of partner selection practices within the emerging cluster. This involved

querying the data to identify patterns between the four categories of location form and dimension and the 10 partner selection activities. First, this was done independently for each category (e.g.: geographic proximity influence only on partner selection); then it was done for the combinations proposed in the conceptual framework (e.g.: geographic proximity/relational proximity influence on partner selection).

## 5.5 Quality of the research

Given the practice-based view of learning and knowing assumes a socially-constructed view of world (Corradi, et al., 2010; Gherardi, 2009a, 2009b; Gherardi, 2009c; Gherardi, 2009d), judgements regarding quality of the research are concerned with trustworthiness of the findings. Trustworthiness concerns whether the findings are sufficiently authentic that future theory development, public policy and managers' practices can be based on it (Lincoln & Guba, 1985). According to Lincoln and Guba (1985) trustworthiness of research can be judged by its credibility, its dependability and its transferability.

Credibility concerns whether the research problem is appropriate for qualitative inquiry (Merriam, 2002). Arguably, understanding learning and knowing practices for knowledge access that are embedded in different fields of practice operating across a number of countries and are influenced by historical institutions is very suitable for qualitative inquiry. Not only does the research concern a complex subject, it also addresses the influence of emergent cluster life-stage and relational location, which are understudied phenomena in the literature. This requires an in-depth contextualised understanding, which makes my research decisions credible.

Dependability concerns whether there is consistency in research design and findings (Denzin & Lincoln, 1994).To ensure dependability the research process, data collection methods and analysis techniques have been outlined and explained to show how these converge. Further description of coding schemas, coding mechanisms and analysis methods are provided in each of the studies. Care has been taken to ensure the findings of each study are independent of the other studies, as well as presenting a coherent programme of research when taken as a whole.

Transferability concerns the extent to which findings can be transferred to other situations (Merriam, 2002).Thick descriptions of the New Zealand innovation system, the Auckland biotechnology cluster and the human therapeutics firms have been provided so the reader can judge the possibilities for transfer into other contexts. When it is unlikely that transferability is limited, care has been taken to note this. For example, in study, one New Zealand's chronic underinvestment in R&D made it an interesting case to analyse but this might limit the transferability of findings to other contexts where investment in R&D is more common. By doing this full and through knowledge is provided for readers' judgement (Merriam, 2002). Overall, through these actions credibility, dependability and transferability of my research can be established. By me taking these actions the research can be considered trustworthy.

## 5.6 Summary of the chapter

This chapter outlined and explained the research approach, data collection methods and analysis techniques used in the research. It summarised the background to the project that informed decisions regarding the research approach taken in the four studies. This included the context of biotechnology development in New Zealand and interest in community of practice as a way of facilitating learning and innovation, which lead me to the research problem. I also outlined how preliminary findings to Research Question 1, which are reported in studies one and two, informed the subsequent decisions. These informed Research Question 2, which is addressed in studies three and four.

# 6. STUDY 1 - SCIENCE MEDIALISATION IN A RELUCTANT KNOWLEDGE-BASED ECONOMY: THE CASE OF BIOTECHNOLOGY IN NEW ZEALAND[1]

Abstract: In the shift towards the knowledge economy, the increased role and value placed on science is associated with an increased medialisation of science. This paper examines how biotechnology is medialised in the context of New Zealand, a society whose knowledge-based development is characterised by belated political reforms, low to medium levels of R&D investment in general and low levels of industry-based R&D in particular. We apply three dimensions of medialisation – extensiveness, pluralisation and controversy – to examine how biotechnology has been medialised in New Zealand over a 15-year period. We discuss how knowledge-based development systems moderate the medialisation of science.

Keywords: knowledge-based development; KBD; public understanding of science; medialisation; biotechnology; New Zealand; NZ.

Science is claimed to be increasingly medialized (Weingart, 1998). This is reflected in increased extensiveness, pluralisation and controversy of issues and opinions reported in the media (Schäfer, 2009) as well as in participation of and contribution by an increased number of stakeholders. There is a shift from science communication as one-way articulation of results

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1 Callagher, L. And Husted, K. (2010) The role of industry R&D in science medialization *International Journal of Knowledge-Based Development* 1(3) pp. 222 -241. 

to public debate about the relevance and reliability of particular science topics. Medialisation is expected to be particularly evident in relation to disciplines that contribute to knowledge-based development (KBD), such as biotechnology, information technology, and nanotechnology(Powell & Snellman, 2004). This paper sets out to investigate whether the extent of medialisation of biotechnology is associated with KBD. We hypothesise that contexts characterised by relatively weak knowledge-based innovation systems and low interaction between the innovation actors lead to a more moderate medialisation of science.

The underpinning arguments for the increased medialisation of science are multiple. To start with, there are observable trends towards increased use of scientific knowledge in arguments for and results of political decision-making and other societal fields (Weingart, 1998). Second, the very process of creating scientific knowledge increasingly takes place in greater interaction with society rather than being focused on science internal criteria (H. Nowotny, Scott, & Gibbons, 2001). The increased medialisation is seen as a break with previous times where the primary focus of science communication was on merely translating science for laypeople and on enhancing the public understanding of science (Gerhards & Schäfer, 2009). This largely one-way transmission model of science communication has been replaced with one that emphasises the need for dialogue between science and the society. Third, there is an increased political and societal influence on how resources for science are prioritised, which, in turn, leads to academic institutions and individual scientists being increasingly involved in or even initiating public debate around their particular research areas. Media is a crucial outlet for those two-way interactions because it provides a powerful medium where actors in the society can initiate, explore and debate about science (Gregory, 2003).

Empirically, medialisation of science has been studied across a wide range of science disciplines (e.g., cold fusion, stem cells, and nanotechnology) and different national contexts (e.g., the USA, the UK, Italy, Germany, and India). Most of the empirical studies have documented the extensiveness of science medialisation (Durant, Bauer, & Gaskell, 1998; Kohring & Matthes, 2002; Priest & Ten Eyck, 2003; Rodder, 2009). However, most of these studies have been conducted in the context of countries with advanced policy frameworks for the development of a knowledge economy that include well-articulated expectations towards science itself and towards the role science play in national innovation systems. For example,

Durant's et al. (1998) multi-country study examined countries which, in line with the Lisbon agreement, invest close to or more than 3% of GDP in research and development (R&D) and countries where there seems to be a general consensus towards the importance of eventually achieving the Lisbon agreement. Despite the rich variety in studies, it is still difficult to draw any more generic conclusions about medialisation of science, partly because of lack of consistency in how medialisation is measured and analysed.

The present paper examines medialisation of science in the context of a society that, according to Engelbrecht (2000), has only belatedly and reluctantly embraced the knowledge economy – New Zealand (NZ). The science system in NZ has a few unique characteristics that make it a fertile context to analyse otherwise well investigated medialisation issues. First, NZ is characterised by a relatively low level of investment in R&D. An investment of only 1.14% of GDP in 2007 places NZ in the bottom third of OECD countries in terms of R&D investments. This investment level has been rather stable over the last ten to 15 years (OECD, 2007). Second, an extremely low level of private investment in R&D (0.498% of GDP) makes NZ one of the few developed societies without a triple helix type configuration of its science system. Instead, the science system in NZ is mainly constituted by two pillars – public science and science policy. This characteristic was further reinforced in 2008 when the newly elected government removed the R&D tax benefit programme only one year after it was introduced by the former government. Third, despite the lack of private investment by industry the previous governments had from the late 1990s consistently tried to push for wealth creation through a clear innovation agenda (New Zealand Office of the Prime Minister, 2002). This has been strongly encouraged by OECD which repeatedly pointed out that the widening gap in NZs productivity compared with similar sized OECD countries (e.g.: Denmark, Norway, Finland and Ireland) is mainly due to a significant underinvestment in R&D.

This paper analyses the specificity of medialisation of biotechnology in NZ. We chose the biotechnology sector because of its traditionally high level of media appearance and its nature of interacting across scientific and commercial spheres and with the society. We specifically examine how biotechnology is medialised in the context of an innovation system characterised by a low level of R&D investment in general, combined with almost non-existent industry-based R&D. We utilise the three dimensions of medialisation as proposed by Schäfer (2009) – extensiveness, pluralisation and controversy – to investigate the changes within the

biotechnology system in NZ over a period of 15 years (1995–2009) and how these changes influence the interaction between science and media.

## 6.1 Theoretical background

KBD proposes a radical shift in thinking regarding the way that knowledge is created and consumed. Rather than a static understanding of knowledge as stocks, attention is paid to the dynamics of knowledge-related processes that are carried by objects and agents across various contexts (Carrillo, 2002). From this perspective, media reports represent objects that carry representations of the views and opinions of various actors that are used in the knowledge processes of debating the role of science in the society.

To deal with the complexity of knowledge-based phenomena that are involved with transforming knowledge resources into local development (Knight, 1995), a systems approach is required (Yigitcanlar, Carrillo, & Metaxiotis, 2010). A systems approach is useful for understanding the interaction among individual, organisational and institutional actors across global and local contexts (Carrillo, 2009) and for understanding why knowledge-based processes are often disputed or contested.

A systems approach to KBD requires strategic action on the part of governments and their agencies to facilitate and coordinate the process of constructing a stronger knowledge base for individuals and firms at national, regional and local levels (Mansell, 2002). Theorising the role of government in facilitating KBD is shared with the systems of innovation approach that recognises the important role of political and institutional factors in influencing the development, diffusion and use of innovations (Edquist, 2005). It is also appreciative of the variation across national (Bartholomew, 1997) and regional systems (P. Cooke, 2002) within biotechnology.

Related arguments regarding the interaction between actors in knowledge-related processes are proposed in sociology of science and organisation of science literatures. Instead of being insular and predominantly relying on strict internal academic quality assurance and being governed by academic norms, science (or at least some scientific disciplines) is said to have opened up towards society, embracing collaborative knowledge production aimed at

solving issues relevant for local stakeholders. This shift towards networked knowledge production has significant implications for the scientific institutions as well as the norms and processes associated with knowledge production. Rather than being exclusively expert-based, strictly discipline-bound and largely self-referential, networked science production transcends disciplinary and institutional boundaries (H. Nowotny, et al., 2001), with research agendas and new knowledge production being continuously (re)negotiated and (re)shaped in interaction among stakeholders in localised contexts (Gibbons, et al., 1994). Consequently, new knowledge within disciplines and fields organised in a mode 2 manner is confronted and tested in different contexts and through public debate rather than being tested against internal disciplinary-bound scientific criteria. The increasing focus on linkages between science and the needs of the wider society also addresses the increasing and explicit societal requirements for more value and clear benefits from invested research funding. This marketisation of science motivates actors in the science system to attempt strategic transformation of the discourse of science and innovation in order to achieve their individual objectives (S. Davenport & Leitch, 2005).

One influential public space where actors in the society initiate, explore and debate these issues is the media. Media is part of a communication system where actors mobilise resources to draw attention to certain issues and activities. Media influences public perceptions through the timing of attention, distribution of awareness and knowledge, directing of attitudes, framing of contents (Bauer, 2005; Priest & Ten Eyck, 2003) and conferring salience on certain issues – "it tells us not what to think, but what to think about" (Gregory, 2003). Because of the abilities mass media (e.g., newspapers, magazines, television programmes) are expected to have a growing importance as a facilitator of the dialogue between science and the wider society. The public communication system shifts from one in which journalists are translators of peer-reviewed science for public consumption towards one in which journalists report on a wider range of actors and their views about networked knowledge production.

Changes in the public communication system challenge the roles of individual actors, institutions and organisations engaged in the system. As well as discussing with expert colleagues through the academy and peer-reviewed publications, individual and organisational actors increasingly must present and debate their views and activities to the wider society and do so in ways that can be understood by members of the society.

An example of these changes is the currently discussed modifications to the performance-based research fund in NZ, a nationwide assessment of the research productivity of academics in the country, to have better meet the demands of private firms. The core argument behind the currently proposed changes in this fund is that while it has been successful in promoting quality improvements in research work, it is not adequately helping the NZ economy to grow. The change proponents note that public investment in research on its own does not drive economic growth and it is firms that translate public research into profit. We expect that there will be an intensive debate around issues such as this and that media will be extensively used as the means through which actors will articulate their arguments.

According to Gregory (2003), in a knowledge society those who are better equipped intellectually to find and use information are more likely to engage in public debate. Hence, media coverage of public debates extends knowledge gaps between the informed and the less well informed because a sufficient level of understanding is needed to enter into the discussion. Furthermore, the exponential growth of science-based knowledge makes it increasingly difficult for non-experts to understand the complexity of knowledge and the debates related to it. Therefore, we expect that participation in public debates regarding science will be dominated by actors who have both an interest and ability to contribute their viewpoints to the discussion.

The incentive for science to initiate and otherwise engage in mass media communication is also related to resource access. Scientists and scientific institutions perceive a need to advocate for increasing resource allocation and expansion of the boundaries around particular scientific activities as actors in the innovation system. Following this logic, the increased political influence on establishing priorities for science funding should lead to an increased willingness of scientists to utilise mass media as a means of gaining political attention to attract funding. Weingart (1998) suggests that this strategy will be most successful in contexts where the role and influence of peer reviews on the allocation of resources is weakened.

An increasing pressure for demonstrating the value that science contributes to society occasionally leads science organisations and their researchers to report results in a manner that over-emphasises potential benefits from research findings (Caufield, 2004). For example, in the late 1990s biotechnology firms used press releases to clearly outline and argue the 'successes' of cloning breakthroughs and articulate their research in a positive way

(McInerney, Bird, & Nucci, 2004). Such reporting has an adverse impact on the public understanding of science-based innovation as the public are provided with a simplistic understanding of the true costs and time-frames involved in commercialising science and KBD. In some cases, as with the publicity around cold-fusion and the following intense academic disagreement about the reliability of the experiments, opening up to the general public has adverse effects on public understanding of why and how scientific breakthroughs are significant. Using science communication in public media as an attempt by scientists to settle conflicts within science might result in confusion and mistrust in the general public towards science rather than leading to a deeper understanding of science as such (Lewenstein, 1995).

Not surprisingly, the relationship between the media and the science community is also contested on a number of dimensions. As a powerful disseminator of knowledge the media have been criticised by the science community for under-reporting (Gregory, 2003), misinformed reporting (Wilkes & Kravitz, 1992) and uncritical and embellished reporting of peer reviewed research (Bubela & Caulfield, 2004). Yet, at the same time, media reporting of science has a positive impact for scientists who do engage with media. Goodell (1977) labels individual scientists with a strong orientation towards mass media as 'visible scientists'. A high media profile not only increases the visibility of scientists in the general public, but it also has also a significant positive impact on scientific reputation (Weingart, 1998). Studies of citation rates for highly visible scientists show that scientists with relative low citations rates before they became visible in mass media experienced a significant increase in academic citations after they had been highly exposed over a longer period in mass media(Weingart, 1998). Therefore, despite these tensions we expect to see an increased coupling of science and medialisation of science.

Medialisation is widely assigned to three dimensions, namely extensiveness, pluralisation and controversy(Schäfer, 2009). Extensiveness refers to the degree of representation of science in mass media. Some studies have argued and empirically supported that a rapidly growing range of popular science journals and television programmes aimed at presenting scientific areas and/or results to the general public reflects an increased extensiveness of science communication.

Pluralisation refers to the degree of diversity in media coverage of science in terms of actors and content. In terms of actors, the public's relationship with scientific knowledge production is constructed through commercial activities as much as through the ideas of the academy. Historically, the commercial sector has been slower than the academy to engage with the public around science(Gregory, 2003). However, as knowledge production often occurs in networks in which public science institutions are involved, private sector organisations might be challenged to engage the lay public in the (re)negotiating and (re)shaping of their research agendas (Gibbons, et al., 1994). One can expect that such negotiations will be articulated in the media.

Pluralisation of content can be understood in regards to the increasing ways that particular issues are framed and augmented. When public opinion in the media and in other public arenas resonates they are framed in ways that inform attitudes on the issue and guide the perception and representation of reality (Goffman, 1974). As frames structure which parts of reality become noticed (Koenig, 2004) we can expect the see a broader use of frames as biotechnology is debated.

Controversy is related to the degree of debate and contention present in the media's reporting of science. The shift towards networked knowledge production changes the interaction among stakeholders about the purpose and value of scientific research (Gibbons, et al., 1994). The mass media is a main outlet where actors in the society can initiate, explore and debate these issues. With a multiplicity of actors, holding differing and often-competing criteria for judging the value of science we can expect to see media reporting increasing controversy of science.

The above three dimensions are somewhat independent of each other in the sense that medialisation does not depend on an equal or simultaneous change on all three dimensions. Furthermore, changes in dimensions are not observed equally across disciplines and contexts which Schäfer (2009) shows is due to the different ways that epistemic cultures influence the medialisation dimensions. Taking the view that science is fundamentally made up of various epistemic cultures that hold different ways of knowing (Knorr Certina, 1999), it can be expected that in the field of biotechnology where epistemic cultures from science, technology and commerce coalesce (Gittelman & Kogut, 2003) medialisation on all dimensions will be high for a number of reasons.

First, fields emerge when social, technological, or economic changes exert pressure on existing relations and reconfigure models of action and social structures (Powell, et al., 2005). Biotechnology is a relatively new field that emerged in the 1970s as private organisations sought to commercially advance public science-based around recombinant DNA. A range of public science actors, including universities, government laboratories and research institutes, as well as other public institutions, established pharmaceutical firms and dedicated biotechnology companies are critical actors in the biotechnology field and it can be expected that they will represent their interests through the media.

Second, biotechnology presents significant opportunities for improving the health and economic wellbeing of societies. This attracts the attention of international actors, such as OECD, the World Bank, the European Commission and the World Health Organisation, who have vested interests in leveraging biotechnology for preventive and curative medicine, food shortages, sustainable fuels and advanced technologies for criminal investigation, among other things. Not only do these KBDs present opportunities to improve the health and living conditions across the world, they also present nation states with very important economic growth prospects (Bartholomew, 1997).

Third, the basis of scientific advancements in biotechnology has the potential to attract attention in regards to the unknown and unknowable consequences of such developments. Major international studies of biotechnology and the media (Bauer & Gaskell, 2002; Priest & Ten Eyck, 2003) have demonstrated a broad interest in public debates about the research direction and potential use of biotechnology. For these reasons, it might be expected that change on the three medialisation dimensions will be associated with different epistemic cultures.

## 6.2 The case of biotechnology medialisation in NZ

NZ has only recently and reluctantly embraced the knowledge economy. Up until the late 1990s reporting about biotechnology in NZ was rare. This is not surprising given consistent underinvestment in R&D, especially private R&D, and limited science commercialisation activity. Towards the end of the 1990s, three sustained news stories directed the public

attention towards biotechnology. Justice legislation introduced in 1996 regarding the use of DNA blood samples in criminal investigations saw a number of high profile legal cases being reported. During 1998–1999, biotechnology was put on the political agenda as part of a national election in which improving the country's productivity through a knowledge society was a central campaign slogan. Shortly following the national election, an application for a scientific trial of genetically modified food brought the genetic modification debate into the daily media. Whilst these three cases brought biotechnology into NZs mass media, it was unclear if they signalled the increasing medialisation of science. The role of public science in any medialisation was somewhat vague and blurred. In the context of low R&D investment, industry engagement in relation to science was expected to be low, leaving increased potential for public science to play a greater role in public debate.

## 6.3 Research approach

To explore the patterns of medialisation outlined above, it was necessary to select analytic frameworks and tools that would identify the pluralisation, extensiveness and controversy dimensions in biotechnology reporting. Using framing theory, we undertook a content analysis of a sample of newspaper articles. We constructed the content analysis in a sequential fashion using the guidelines outlined below. However, for the purposes of this paper, we will present our findings in the next section using Schäfer's (2009) medialisation framework.

Content analysis, which involves the conversion of text into numerical variables for quantitative data analysis (Collis & Hussey, 2003), was selected to analyse patterns of media reporting because it enabled us explore a large number of newspaper articles over an extended period of time to identify the ways biotechnology was framed and the actors' views reported. Content analysis was undertaken on data from the period January 1995 to December 2009, as public debates outlined above were known to have occurred during this period. A dataset covering a time period of 15 years was important because it provided an index of the intensity of reporting and a measure of changing salience over time (Bauer & Gaskell, 2002). It also enabled us to determine the extensiveness dimension of medialisation.

The unit of analysis was the newspaper article in which biotechnology appears as a focus. Following the approach of Bissell (2000) and Holdford and Yom (2003), a daily national newspaper, The Dominion Post, was searched via the ANZ Reference Centre database for articles associated with biotechnology. We selected The Dominion Post because among the three daily newspapers published in NZ, it is best recognised for covering national, political and business news. In contrast the NZ Herald concentrates on business news rather than politics and The Press focuses in local and regional news of special interest groups (Rupar, 2006). While analysis of all three sources is likely to identify differences in the reporting patterns among them, our aim is to explore the interaction between KBD and medialisation, rather than a comparative media analysis.

**Table 6.1 Sampling of articles by year**

| Year | Total number of articles by Year | Initial 10% stratified sample | Cleaned Sample "biotechnology focussed" |
|---|---|---|---|
| 1995 | 226 | 23 | 11 |
| 1996 | 166 | 17 | 9 |
| 1997 | 211 | 22 | 8 |
| 1998 | 215 | 22 | 6 |
| 1999 | 256 | 26 | 11 |
| 2000 | 316 | 32 | 8 |
| 2001 | 344 | 35 | 17 |
| 2002 | 352 | 36 | 16 |
| 2003 | 278 | 28 | 12 |
| 2004 | 200 | 20 | 13 |
| 2005 | 240 | 24 | 10 |
| 2006 | 354 | 36 | 11 |
| 2007 | 379 | 38 | 9 |
| 2008 | 294 | 30 | 5 |
| 2009 | 264 | 27 | 6 |
| TOTAL | 4095 | 416 | 152 |

Using Bauer and Gaskell's (2002) sampling method, the search string 'biotech* or genes or genet* or genom* or DNA or clon* or ivf or intro or vitro or 'test tube bab*' or 'stem cell' or 'clinical trial' or bio or bio waste or 'medical device' or 'medical imaging' or 'medical diagnostic' or biochem* or 'functional foods' or nano*' identified 4,095 articles. From the total number of articles, a 10% stratified sample (416 articles) was selected. This was achieved by

listing every article for each calendar year in chronological order of publication and then selecting every seventh article until we had 10% of that year's total articles. To ensure that articles covered the whole period (Altheide, 1996) this was done for all 15 calendar years to provide the initial sample (see Table 6.1).

However, early on we noted that a reasonable proportion of the articles in the stratified sample were not about biotechnology per se. Thus, we had to clean the data further. Following the method used by Horst (2003), we categorised articles in the stratified sample as having a biotechnology focus when the biotechnology topic was articulated in a full paragraph (i.e., more than one sentence). Articles that did not fulfil this criterion were disregarded during the cleaning process. This left us with a final sample of 152 biotechnology-focused articles for analysis.

The content of daily newspaper reporting was analysed using framing theory. Framing theory is commonly used in the analysis of media reporting because it helps illuminate how certain representations of 'truths' become noticed, negotiated and adopted into the society through a public communication process. Table 6.2 presents an overview of the research questions, the dimensions of medialisation and the media frames.

**Table 6. 2 Main dimensions of research design**

| Research Aims | Dimensions of Medialization | Media Frames |
|---|---|---|
| We set out to investigate the ways in which biotechnology is medialized in the context of a reluctant knowledge based economy. More specifically we aim at:<br>- tracing the development of debates in various frames associated with biotechnology in NZ, and,<br>- examining the role of public science in those debates. | Extensiveness | Horst's (2003) biotechnology focus criteria |
| | Pluralization | a. Schäfer's (2009) Scientific, Political, Economic and Ethical-legal-social frames<br>b. Bauer and Gaskell's (2002) Main Reference Actor frames |
| | Controversy | a. Durant and Bauer's (1998) impression scale<br>b. Two-way dialogue using Bauer and Gaskell's (2002) Main Topic frames |

To assess the extensiveness dimension, we applied Horst's (2003) biotechnology focus criteria during the sampling process. This provided us with an indication of the trends biotechnology-focused reporting viz-a-viz other reporting using biotechnology terminology.

Pluralisation relates to the diversity of content and diversity of actors. We used two measures to account for these different aspects. Four frames, scientific, political, economic and ethical-legal-social, distinguished by Schäfer (2009) were applied to assess the pluralisation in terms of the way that biotechnology content was reported. The scientific frame includes the reporting of scientific 'facts', experts' evaluations of scientific research and its implications, and discussions regarding scientific knowledge systems and norms. The political frame concerns the regulation of science by non-scientists, such as political, judicial or general public discussions regarding the valuation and control of science priorities. The economic frame refers to economic and commercial aspects of science and research. The ethical, legal, and social frame relates to debates about the relationships between science and human nature to include issues such as intellectual ownership and ethical issues regarding medical intervention. Each of the 152 articles in our final sample was categorised against one of these four frames.

To measure pluralisation of actors, we applied frames from Bauer and Gaskell (2002) to identify the main reference actors in the sample articles. Given our interest of medialisation and KBD, we then grouped the main reference actors into four groups identified with KBD in the innovation system. These were: 1) firms, 2) science policy, which included government departments and their agencies, as well as members of parliament (i.e., elected Ministers and the Prime Minister), 3) public sciences, which included NZ universities, public research organisations referred to the NZ context as Crown Research Institutes (CRIs) and other public science beyond NZ, and 4) public, e.g., individual citizens, non-governmental institutions, judicial actors, and stakeholder groups

Two measures were used to assess the controversy dimension of medialisation. First, we applied a measure of the overall impression about biotechnology. Using Durant's et al. (1998) five-point scale each article was coded from highly positive to highly negative in regards to the overall impression about biotechnology. Highly affirmative referred to reporting in a very enthusiastic tone with great promise, affirmative referred to enthusiastic tone of promise,

neutral referred to a reporting tone in a neutral tone, negative referred to a tone of some concern and highly negative referred to a tone of great concern or doom.

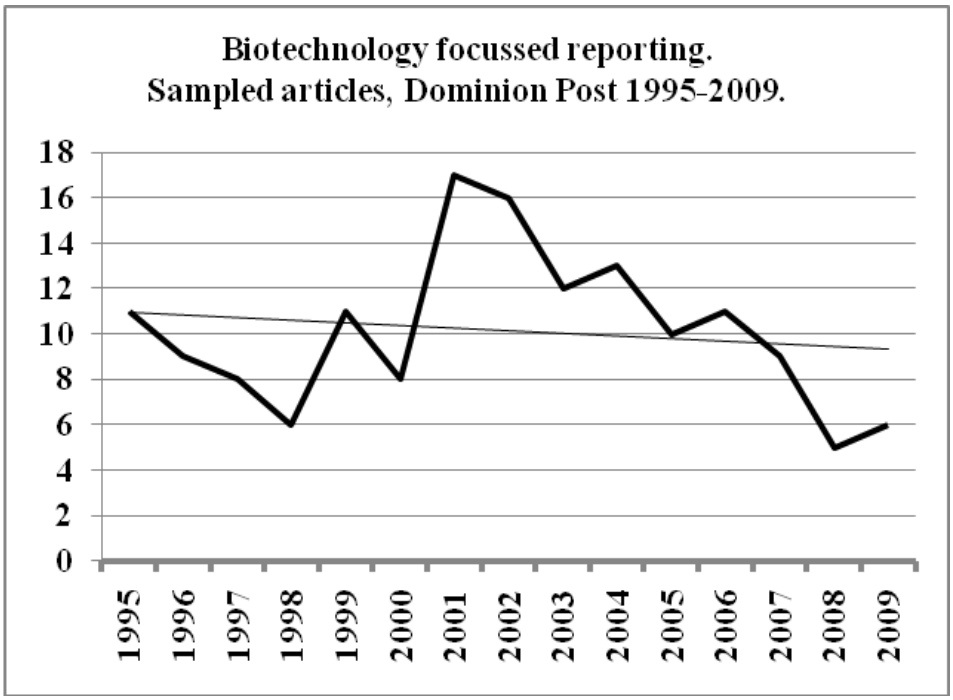
Next, we identified two-way dialogue about biotechnology issues between actors within the sample articles. We applied content frames from Bauer and Gaskell (2002) to categorise the articles in terms of the first and second main biotechnology topics they were reporting on. The topic categories were: agricultural biotechnology, horticultural biotechnology, biofuels, biodiversity-organics, economic prospects, education, science literacy, ethics, financial-venture capital-investment, gene identification as diagnosis, prediction, testing, gene identification for 'finger printing' or for other legal purposes, gene identification for other purposes, medical testing, patenting-intellectual property-legal issues, pharmaceuticals, neutraceuticals, reproduction-in-vitro fertilisation, safety-risks (to food, environment or workers), science policy, general transgenic, transgenic-GMO release specific, and transgenic-xenotransplantation specific. Using inductive pattern searching (Gibbs, 2002), articles within each content frame were compared to identify where reporting of an issue had lead to subsequent reporting on the same issue. With the relatively small sample size, it was also possible to compare articles published in the same year for related reporting on similar issues. Using these pattern matching methods, we identified sustained news stories over the 1995–2010 period.

## 6.4 Findings

We find evidence of low levels of medialisation on all three dimensions – extensiveness, pluralisation and controversy. On the extensiveness dimension, medialisation reflects an increased reporting of science in the media. As outlined in the previous section, raw data from our initial search suggested a general trend towards extensiveness due to the general increasing trend in the number of articles referring to biotechnology. However, when Horst's (2003) biotechnology focus criteria were applied, we found that reporting on biotechnology was not as prolific as the initial search had led us to believe (see Figure 6.1). Rather than a general trend towards increased reporting that focussed on biotechnology over that period, which has been reported in most other medialisation studies, incidences of biotechnology

reporting in NZ had fallen. This suggests that while biotechnology-related terms became increasingly familiar in the public lexicon, issues related to it were not publically debated through the mass media in any ever-increasing way.

**Figure 6.1 Biotechnology focussed reporting**

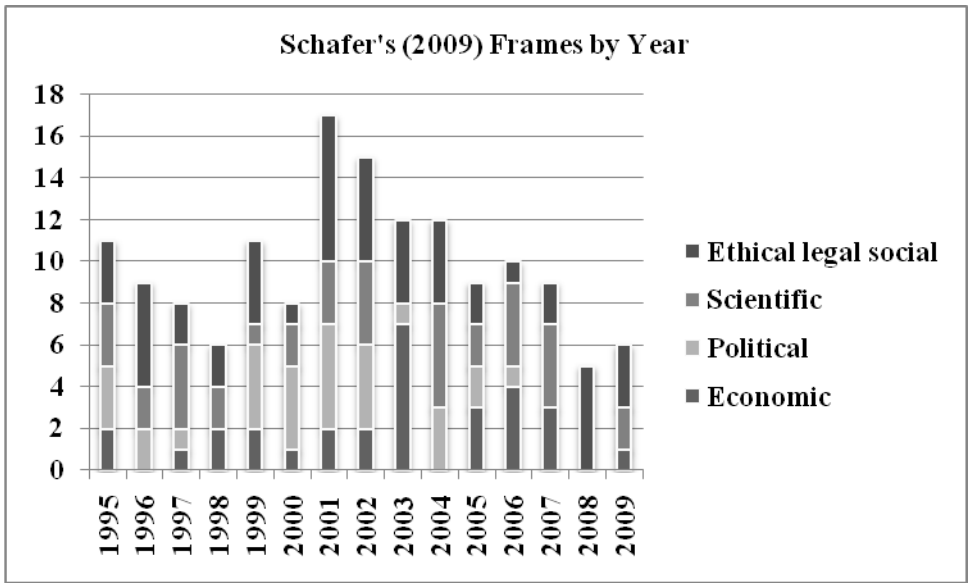



Where reporting activity did escalate, it was for identifiable periods of time and in relation to specific debates. Increased reporting towards the end of the twentieth century to peak around 2001–2002 coincided with public debates related to the governance of genetic modification and the use of DNA technology in the justice system. However, in the following period, i.e., from 2002–2003 onwards, biotechnology focus reporting trended downwards. This leads to us to conclude that on the extensiveness dimension biotechnology focused reporting in NZ during 1995–2009 experienced unchanged levels of medialisation and that any increase in medialisation was associated with general familiarity with the topic, not increased debate.

We measured the pluralisation dimension of medialisation by increased diversity of coverage and increased diversity of actors. In a medialised environment, it is expected that the scientific frame is tempered as other frames become more widespread (Weingart, 1998). However, we did not see this pattern in our data (see Figure 6.2). The scientific frame, which

represents the traditional view of one-way science communication, remained consistent over the 1995–2009 period. Increased use of the political and ethical-legal-social frame was seen for short periods during specific debates only, but overall these fell slightly. Any continued pluralisation of coverage over the wider period was limited to the growth of the economic frame. This leads us to conclude that in terms of diversity of coverage medialisation was low.

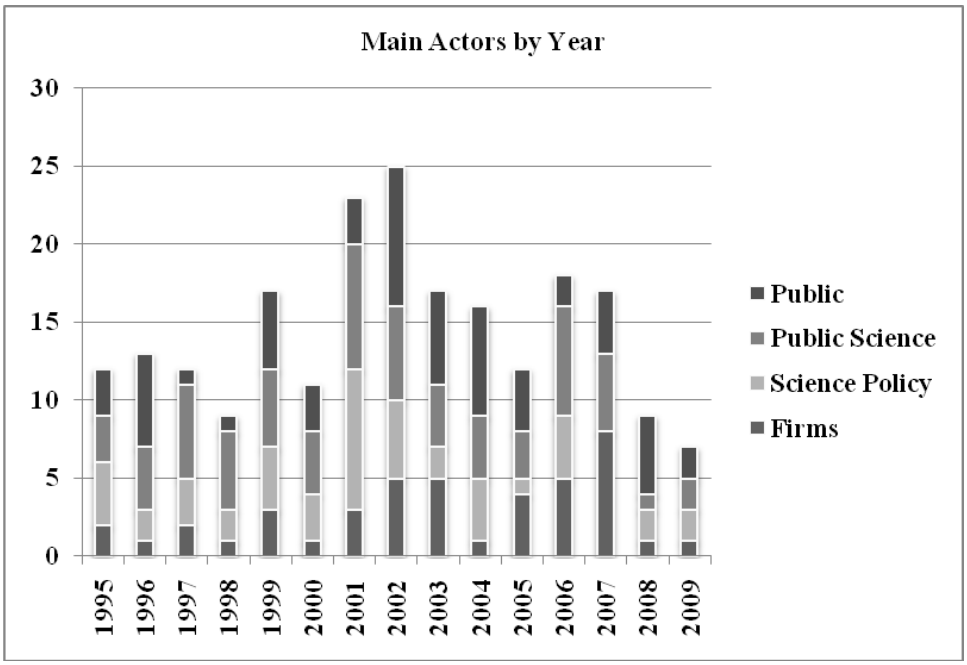
**Figure 6.2 Schafer's (2009) frames by year**




The second measure of pluralisation relates to increasing diversity of actors whose views are represented in biotechnology reporting. Given our interest in NZs weak conditions for KBD, we present the data about the diversity of firms, public science, science policy and public as main actors influencing the direction of science in the national innovation system.

As illustrated in Figure 3, during the 1995–2009 period the views of some actors were reported more prevalently than others. Traditionally it is not common for firms to be reported as main actors in biotechnology reporting (Gregory, 2003). However, in our data Firms increased four-fold over the 1995–2009 period. We were not surprised by this trend given the global economic opportunities that have been touted for the biotechnology industry and local efforts by successive governments to facilitate private R&D in the national innovation system. The public (i.e., individual citizens, non-governmental institutions, including judicial actors, and stakeholder groups) also increased slightly.

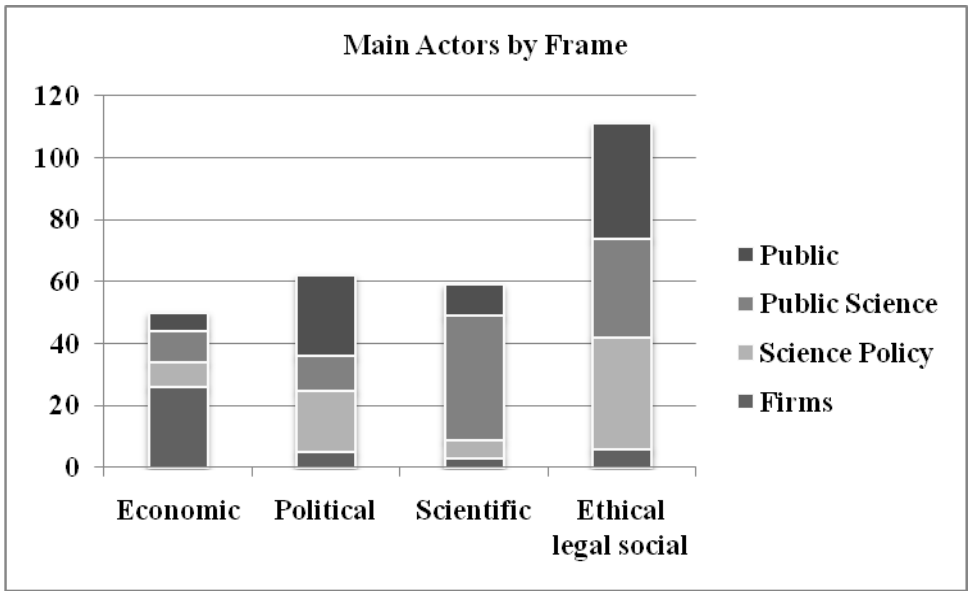
**Figure:6.3 Main Actors by year**




In contrast, science policy, which included government departments and their agencies and members of parliament, and public science, which represented NZ universities, Crown Research Institutes and other universities, both fell over this period. This is a somewhat surprising finding because NZ's KBD still relied on these main actors to maintain science in the innovation system. In addition, successive governments had put extended effort into orienting policies and associated funding mechanisms towards entrepreneurial and commercial activities in collaboration with public science. We elaborate further on why we would have expected public science to debate these topics in the next section.

When we looked closer and compared the frames that main actors were reported using, we found that the differences between firms, public science, science policy and public were strongly associated with particular ways of presenting biotechnology (see Figure 6.4). Firms were strongly oriented toward the economic frame with them five times more likely to be reported using an economic frame than any of the other frames. Public science was strongly associated with the scientific and ethical-legal-social frames. The association of public science to the scientific frame is the traditional role of science in the communication system (Gregory, 2003; Bauer and Gaskell, 2002) which suggests that the traditional role of public science remained strong in the NZ context.

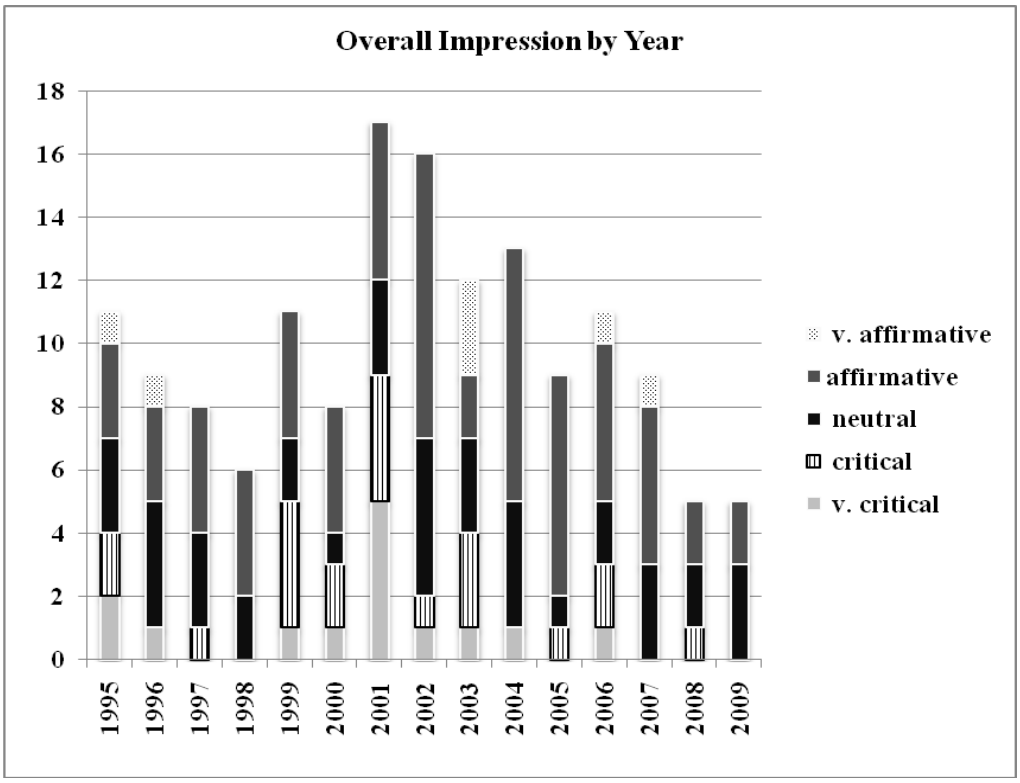
**Figure 6.4 Main actors by frame**




Science policy and public were mainly reported using the ethical-legal-social frame and the political frame to a lesser extent. These trends broadly reflect patterns in other studies of the increasing role of the society in evaluating the role of public science (Nowotny et al., 2001). However, as noted earlier, the extensiveness of that debate was much lower in NZ compared to the other OECD countries. Given that the overall patterns show actors being reported using traditional media frames, we are led to the conclusion that on the pluralisation dimension, medialisation can be described as moderate.

Controversy is the third dimension of medialisation and was measured using two methods. The first was the overall impression of biotechnology in each article and the second method was by the number and nature of two-way dialogue about biotechnology issues. In terms of the overall impression of biotechnology, we found that the general trend over the 1995–2009 period was towards an increased affirmative impression of biotechnology reporting and a decreased critical impression (see Figure 6.5). Public debate about biotechnology in other studies has been reflected by an increased diversity of views as competing viewpoints are articulated as argument and counter argument leading to a wider range of impressions being reported (Priest and Ten Eyck, 2003; Bauer, 2002). However, we did not see a general trend towards increased controversy in the NZ context. In fact, we see a strong trend towards biotechnology being reported in an affirmative way, which implies a broad acceptance. This leads us to conclude that on this measure, the controversy dimension of medialisation is low.

**Figure 6.5 Overall impressions by year**




The second measure of controversy was to identify two-way dialogue about biotechnology issues. Concurrent reporting of affirmative and critical impressions is likely to indicate controversy around an issue and there was limited evidence of this in our data. Using the pattern matching method outlined in the previous section, we identified two issues where two-way dialogue was reported. The issues were about genetic modification and the use of DNA in the justice system.

Dialogue about genetic modification began in 1999 through a series of reports where a Crown Research Institute (CRI) defended its actions in applying to a government agency for approval to undertake a genetic engineering trial in cows. As well as defending its research application, the CRI criticised the opinion of a member of parliament who had questioned the efficacy of the trial and charged the member with 'scare-mongering'. The debate continued throughout 1999 with a number of main actors predominantly using political and ethical-legal-social frames to present their views. The debate continued through 2000 culminating in a Royal Commission in Genetic Modification in October and although the total number of

articles reporting biotechnology dropped in 2000, 75% of the articles we sampled continued to be concerned with the Royal Commission in Genetic Modification.

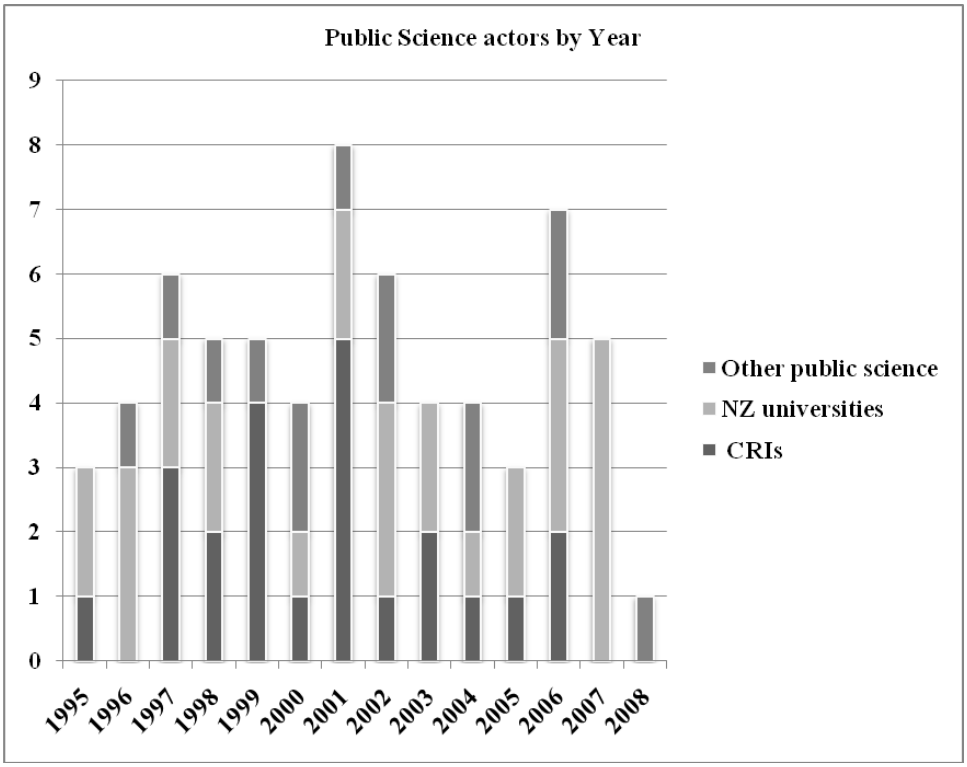
Domination of biotechnology reporting continued through the first half of 2000 culminating in the completion of the Royal Commission in June of that year. The GM debate was reignited in July 2001 following the Royal Commission's report. The genetic modification debate accounted for 30% of biotechnology reporting in 2001 and a variety of main actors debated the Royal Commission findings. However, by 2002 the genetic modification 'debate' had ended. Although one or two genetic modification-related articles appeared in our sample in subsequent years, they did not attract the two-way dialogue that was observed over the 1999–2001 period.

The second two-way dialogue related to the use of DNA in the justice system and similar to the genetic modification debate, it was dominated by use of the ELS frame. This issue first appeared in the media in 1995 when the investigation (blood samples) bill and its subsequent passing into legislation put focus on the use of DNA databases in criminal investigation. Initial reporting used the ELS frame to debate the legal arguments for and against the development of a database and continued to be the main frame used to report on the identification and charging of offenders. In 1997, DNA evidence was used to overturn a high-profile child rape conviction. The ensuing claim for compensation by the wrongly accused man that was disregarded by the Justice Minister attracted strong public interest and included calls for a public inquiry into the role of DNA technologies in addressing historical legal cases. This debate reignited in 2001 when advanced DNA technologies were applied to the DNA samples from an unsolved 1980s child rape-murder case. These led police to announce that the case was active again as the new results gave them strong leads. Within days of the announcement, a man had been charged based upon DNA evidence. Debate about the role of DNA continued throughout the trial and subsequent conviction when the same DNA database identified the accused man's father for historical sex crimes from the 1970s.

These two-way dialogues are evidence that controversy was debated in the media during the 1995–2008 period and that different actors did engage. However, it also illustrated that rather than being a constant feature of the media system, controversy only occurred around particular issues only. This leads us to conclude that in using two-way dialogue as a measure, the controversy dimension of medialisation was low.

As well as the development of two-way dialogue as a measure of controversy, we were also interested in the role of public science in those debates. To understand the role of public science better, we considered NZ universities, CRIs and other public science as sub-categories. Dividing public science is useful because there are intriguing differences in their changing roles regarding biotechnology reporting (see Figure 6.6). Over the 1995–2009 period reporting of NZ universities as main actors increased, whilst reporting of CRIs and other public science as main actors reduced. This is intriguing to us because CRIs were influential actors in the controversies that involved two-way dialogue. In fact, CRIs were central players in the initial debate about genetic modification and their views were commonly reported in relation to the development and use of DNA technologies in the justice system.

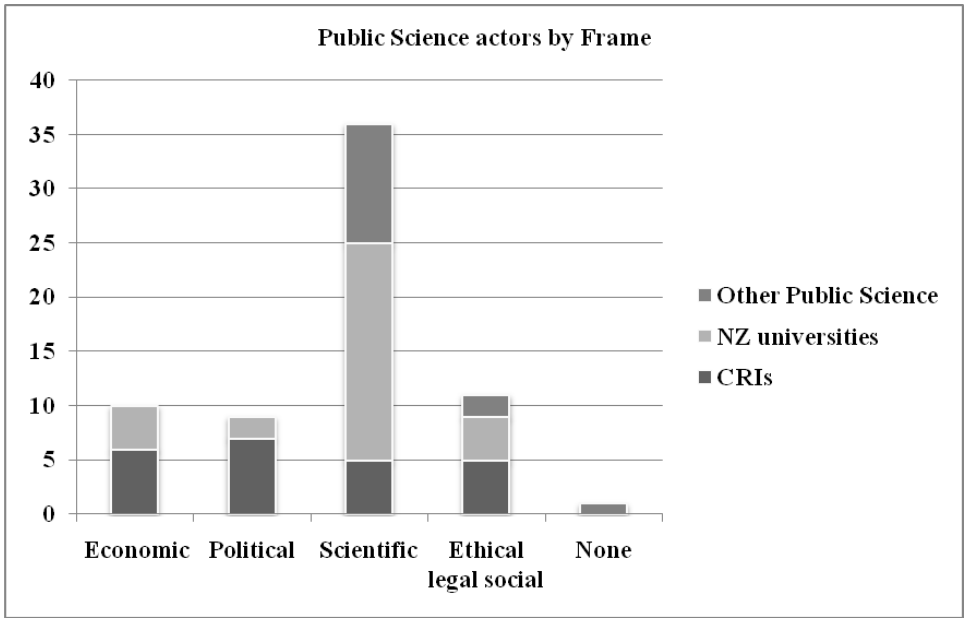
**Figure 6.6 Public science actors by year**




The changing patterns of the reporting of views in public science are further complicated when the frames used are considered (see Figure.6.7). We found that NZ universities and other public science institutions were most commonly associated with the scientific frame suggesting they are mostly oriented towards the traditional view of science communication. NZ universities were rarely reported using the political frame. This is unexpected because during the 1995–2009 period a number of significant policy changes were signalled and

implemented that had direct and multiple impacts on the university environment. Despite these well signalled policy changes there was no evidence in our sample of NZ universities articulating their views through the media. Whilst such articles can be found with a specific search of the ANZ reference centre database, they are not in any prolific number that they are representative of biotechnology reporting. CRIs on the other hand were reported using all of Schäfer's (2009) frames. Evidence of their role in the two-way debates showed CRIs engaging in reporting about their own projects, governance issues that affect their future action and the economic value of science. Therefore, even though the amount of reporting of CRIs as main actors had reduced, the frames used had increased, suggesting that CRIs behaved differently as compared to their NZ university counterparts.

**Figure 6.7: Public Science actors by frame**




## 6.5 Discussion and conclusions

Given the medialisation of science and continued changes towards debate-based approaches to science communication that are discussed in the literature, we anticipated relatively strong representation of biotechnology in the media. In the NZ context, where KBD attempts to address the weak innovation system have occurred only recently, we expected that public science would play an important role in the medialisation process. However, our study found little evidence to support this. Furthermore, we found different patterns of

reporting among public science actors and some of those patterns were associated with traditional views of science in the society. Given that the medialisation of science is a phenomenon that invokes multiple actors to interact through the communication system of mass media, our explanations of the medialisation phenomenon consider arguments at different levels of the communication system.

The KBD perspective claims that a systems approach is critical to understanding the transformation of knowledge resources from the global to local level (Yigitcanlar et al., 2010). Mass media provides an outlet where a wide array of actors can participate in debate regarding the resourcing and direction research agendas within the innovation system. However, in the NZ context where the innovation system is characterised by weak industry participation, actors (i.e., firms) lack a tradition of debating science in the media. In this context, we might expect other actors, namely science policy and public science, to play a stronger role in public debates. In this study, we found that the reporting of science policy and public science actors decreased. Furthermore, these actors were predominantly reported using traditional frames associated with traditional perspectives on the role of science in the society. These patterns were irrespective of concerted efforts by the government to strengthen the KBD environment through an explicit innovation framework and research, science and technology policy.

KBD requires strategic action on the part of governments and their agencies to facilitate and coordinate the process of constructing a stronger knowledge-based for individuals and firms at national, regional and local levels (Mansell, 2002). Such an approach also requires participation by the other actors in the innovation system to exploit local knowledge opportunities created. Our findings suggest that the NZ universities have not responded to the government's KBD attempts. This could be problematic for NZ's goal to develop a knowledge economy. NZ universities' continued orientation towards the scientific frame limits their ability to engage in debate with other actors about the direction and priority of future research. These tendencies draw attention to the difficulties that actors face in operationalising their obligations and changing their traditional patterns of behaviour.

Part of the challenge of KBD relates to creating local contexts where stakeholders' boundaries can be transcended. Actors involved in the media system reside in various epistemic cultures. In these cultures, belonging members subscribe to, identify with and share

specific ways of knowing and communicating. Mass media presents a meta-world where actors from different epistemic cultures meet. In order for ideas to be understood and debated across epistemic cultures however, a sufficient level of understanding across epistemic cultures is necessary. Additionally, actors can communicate across epistemic cultures only when they are curious enough to seek out different experiences and are committed to developing their understanding of other cultures (Unruh, 1979). Our research suggests that in the NZ context too few actors were able to engage across epistemic cultures and/or were unwilling to develop the skills necessary to do so. Hence, actors, in general, were ill prepared to participate in debates and instead continued to use their traditional frames of thinking and failed to participate in the media through a more diverse range of frames allowing them to interact with other epistemic cultures. The overall consequence is limited instances of genuine debate.

This leads us to conclude by pointing out an important avenue for future research regarding the limits to government attempts at facilitating knowledge transformation in the knowledge system. Mansell (2002) points to a number of barriers that governments face in coordinating amongst their own agencies. The NZ experience also suggests that attention needs to be paid to understanding the limitations of these facilitating attempts. Furthermore, we believe it to be a line of research that can be fruitfully explored within the emerging KBD field.

# 7 STUDY 2 - EXPLORING FIRMS' RESPONSES TO INNOVATION POLICY: EVIDENCE FROM AN EMERGING BIOTECHNOLOGY CLUSTER

Abstract: Biotechnology firms are claimed to gain innovation advantages from localised knowledge processes. These benefits maintain public policy interest in stimulating innovation through industrial clusters in regional innovation systems. However, the effect of innovation policy on firms' knowledge processes is difficult to assess, especially when innovation policy is a combination of policies. Conceptualising firms' knowledge processes through communication channel use; this study explores firms' responses to a decade of innovation policy. Based on an embedded case study of firms in a biotechnology cluster in Auckland, New Zealand, findings suggest that while firms' communication 'buzz' was broadly promoted, firms' heavy use of communication 'pipelines' experienced limited policy support. Firms' communication channel use suggests that policy-makers revise current innovation policy towards biotechnology firms' local and global links.

Since Porter's (1990) work on national competitiveness, industrial clusters in regional innovation systems have been presented as a policy solution to innovation and economic growth (P. Cooke, 2002). Clusters may be spontaneous or policy-driven (Chiaroni & Chiesa, 2006), they may be implemented top-down or bottom-up (Fromhold-Eisebith & Eisebith, 2005), they may be competitive or cooperative (Newlands, 2003). A review of these literatures suggests that firms involved in such clusters gain a number of innovation benefits related to localised knowledge processes.

Because of the production of new goods or services usually involves the creation and integration of different types of knowledge, knowledge is a core feature of firms' innovation (Kogut & Zander, 1992; Nonaka & Teece, 2001). Localised processes facilitate the production and sharing of implicit and tacit knowledge through face-to-face communication, body

language and in-situ demonstration (Howells, 2002). The importance of localised knowledge processes has led governments to facilitate institutional and organisational arrangements that encourage industrial clustering (Boekholt & Thuriaux, 1999).

Although much attention has focussed on developing innovation policy, less attention has been given to evaluating the effects (B. Lundvall & Borras, 2005). The lack of systematic methods for analysing the effects of public policy complicates attempts at understanding how innovation policy can influence innovation (Raines, 2002). Furthermore, the fact that innovation policy is usually not one policy, but a combination of initiatives from a number of portfolios further compounds attempts at assessing the effects of innovation policy. Nonetheless, the extended efforts of governments to develop and implement innovation policy to foster industrial clusters does require further investigation to establish how these policies influence firms' innovation-related knowledge processes.

This study investigates the effects of industrial clusters and innovation policy on firms' knowledge processes used for innovation. Knowledge processes refer to a collection of processes used for creating, sharing, transferring, integrating and using knowledge (Foss & Michailova, 2009). As relational phenomena knowledge processes can be difficult to discern until they become obvious, such as when they are talked about or written about (Patriotta, 2003). Therefore, by conceptualising firms' knowledge processes as firms' communication channel use, the influence of industrial clusters and innovation policy on firms' innovation can be examined.

The study makes two important contributions to the industrial clusters and regional innovation systems literature. First, examining biotechnology firms' communication channel use reveals that innovation policy has both intended and unintended consequences. In order for public policy to foster innovation, it is necessary to evaluate the effect that policy has on firms as well as clusters. This suggests the need for a multi-level approach to policy evaluation that captures innovation policy effects for cluster development and firms' innovation.

Second, examining communication channel use demonstrates that biotechnology firms rely on local and global knowledge processes for their innovation. While other scholars have reported biotechnology firms' use of local-global knowledge links (M. S. Gertler & Levitte, 2005; Franz Todtling, et al., 2006; F. Todtling & Trippl, 2007), this study suggests policy-makers revise innovation policy to support both local and global knowledge processes.

The paper is structured in the following way. I outline why industrial clusters are associated with firms' knowledge processes and innovation. I explain why firms' knowledge processes can be conceptualised through their communication channel use using Balthelt, Malmberg and Maskell's (2004) cluster communication theory that identifies pipelines, buzz and face-to-face as communication channels. I outline the embedded case study approach and describe the empirical setting, including industrial cluster and the innovation policy. I present the findings about firms' communication channel use and discuss the effect of industrial clusters and innovation on firms' knowledge processes. I conclude by arguing for a multi-level approach to innovation policy evaluation and suggesting that policy-makers revise innovation policy to support both local and global links.

## 7.1 Industrial clusters, innovation policy and firms' knowledge processes for innovation

In this section, I outline the relationship between industrial clusters, innovation policy and firms' knowledge processes for innovation that has been described in the literature.

### 7.1.1 Industrial clusters and knowledge processes

The nature of knowledge is a starting premise for a number of arguments about the relationship between industrial clusters and innovation. Knowledge has both codified and tacit aspects (Polanyi, 1967). Tacit aspects refer to habits, routines and subconscious understandings that cannot be articulated through language (Tsoukas, 2002). However, geographic proximity can support tacit knowledge sharing because rich information medium can transfer subtle cues that are necessary to making sense of those tacit aspects (Daft & Lengel, 1986).

Audretsch and Feldman (1996b) argued that geographic proximity matters mostly during the early stages of the industry life cycle because this is when tacit knowledge is most important for innovative activity. Analysing the citation and location data of 2400 commercial innovations, they found the propensity to cluster is greatest in industries, such as

biotechnology, that are dependent on accessing new economic knowledge. In her study of the formation of US biotechnology clusters Prevezer (1997) argued the presence of a strong science base is a critical input for biotechnology firms' innovation.

Industrial clusters also enable learning-by-doing and vicarious learning where knowledge can be created and exchanged (M. Gertler, 2003). According to Agrawal (2006) a strong science base is important because biotechnology firms use latent knowledge in their R&D. Latent knowledge refers to knowledge that can be codified if required (Agrawal, 2006). Since the proofs of concept that biotechnology firms acquire from universities need further development (Jensen & Thursby, 2001), latent knowledge sharing between inventors and biotechnology firms is important for firms' innovation.

Since industrial clusters provide geographic proximity, they support knowledge sharing because firms can gain faster access to information compared to non-clustered firms (Bell, 2005). In biotechnology clusters firms are known to have access to knowledge and opportunities that are not available to non-clustered firms (Owen-Smith & Powell, 2004). Industrial clusters facilitate different knowledge sharing mechanisms, including market relations, formal networks, and informal links (F. Todtling & Trippl, 2007). In summary, industrial clusters support knowledge creation, sharing and use by biotechnology firms for their innovation.

### 7.1.2 Innovation policy and knowledge processes

Given the benefits of industrial clusters, innovation policy has been used to facilitate industrial cluster development and various methods have been devised to assess the effect of innovation policy on industrial clustering (Roelandt & den Hertog, 1999). While the field has established that innovation policy can support industrial clustering, it is less clear how innovation policy influences firms' knowledge processes.

One reason why it is not clear how innovation policy influences firms' knowledge processes is that systems of innovation perspectives are more concerned with macro-level analysis of the innovation system. Innovation policy is often government policy at the national level that seeks to influence the national and regional innovation systems (B Lundvall, 1992). Focus on these more macro-levels reflects that regions are important bases for governance and

economic coordination (B. T. Asheim & Isaksen, 2002; P. Cooke, Uranga, & Etxebarria, 1997). While it is important to understand these national-regional interactions, it is equally important to examine interactions across multiple levels of the innovation system in order to understand how firms benefit.

Another reason why innovation policy affects on firms' knowledge processes are difficult to explain is that innovation policy is a portfolio of policies, rather than a single intervention. According to Lundvall and Borras (2005) innovation policy is usually driven by a number of policies. Research, Science and Technology policies (RS&T) support basic and applied research and development, Industrial and Economic Development policies (I&ED) foster entrepreneurial growth, and, Education policies (ED) facilitate interactive learning across the innovation system. Accounting for the effects of concurrent policies on innovation requires a research design that can account for these numerous interactions of policies influencing firms' knowledge processes and policies interacting with each other. Accounting for concurrent policies is further compounded because policy initiatives in one area can have negative effects in other parts (Oughton, Landabaso, & Morgan, 2002).

A third reason why innovation policy affects on firms' knowledge processes are difficult to explain is that policies can take some time to take effect. According to the knowledge-based development perspective, governments use innovation policy to influence institutions affecting local interactions (Carrillo, 2002). Institutions refer to sets of common habits, norms, routines, established practices, rules and laws that regulate relations and interactions between individual, groups and organisations (Edquist, 2005). Since institutions are the result of historical patterns of activities and can take years to change, a longitudinal approach is needed to understand how innovation policy influences firms' knowledge processes.

The fourth reason why it is difficult to explain the influence that innovation policy has on firms' knowledge processes is that knowledge processes are difficult to operationalise. Spender (1996b) argued that clear constructs for firms' knowledge processes are difficult to specify because the types of knowledge used cannot be divorced from each other. Nonetheless, different knowledge types and processes can be observed in firms' communication patterns (Maula, 2000). Therefore, one way to overcome the challenge of specifying and observing firms' knowledge processes is to conceptualise them as firms' communication channels.

## 7.2 Conceptualising knowledge processes as communication channels

In order to operationalise firms' knowledge processes, I conceptualise them as communication channels. Bathelt et al (2004) theorised three communication channels associated with industrial clusters: face-to-face, buzz, and pipelines. In this section, I outline the three communication channels and explain why they provide a heuristic for analysing firms' knowledge processes for innovation.

Face-to-face communication channels (face-to-face) refer to in-person interactions that occur in the same physical space (Bathelt, et al., 2004). Face-to-face is fundamental to industrial clustering because it is the primary means of sharing implicit and tacit aspects of knowledge (Storper & Venables, 2004). It also supports the transfer of complex knowledge between actors with loosely related meaning systems because actors can use non-verbal cues, such as facial expressions, hand gestures, mimicry and modelling to enrich explanations and check interpretation (Mengis & Eppler, 2008). Face-to-face also provides a means for undertaking an evaluation of an actor's competence, which is important because knowledge sharing requires a degree of trust (Das & Teng, 1998).

Buzz communication channels (buzz) refer to regular face-to-face communication among a group of actors operating in a shared field that is in the same geographic location (Storper & Venables, 2004). Buzz acts as a communication channel by providing a broadcasting role that makes existing knowledge within an industrial cluster known to other members (Bathelt, et al., 2004). Unlike face-to-face, which requires actors' presence and effort, buzz requires little additional investment because people share knowledge that they have gained through other channels (Grabher, 2002). Buzz is often associated with creative industries where project-based organisations are commonly used to combine different sources of knowledge for particular tasks (Florida, 2002). However, other industries increasingly use projects as a method for organising (Hagedoorn, 2002) suggesting that analysis of communication channels should consider buzz irrespective of industrial context.

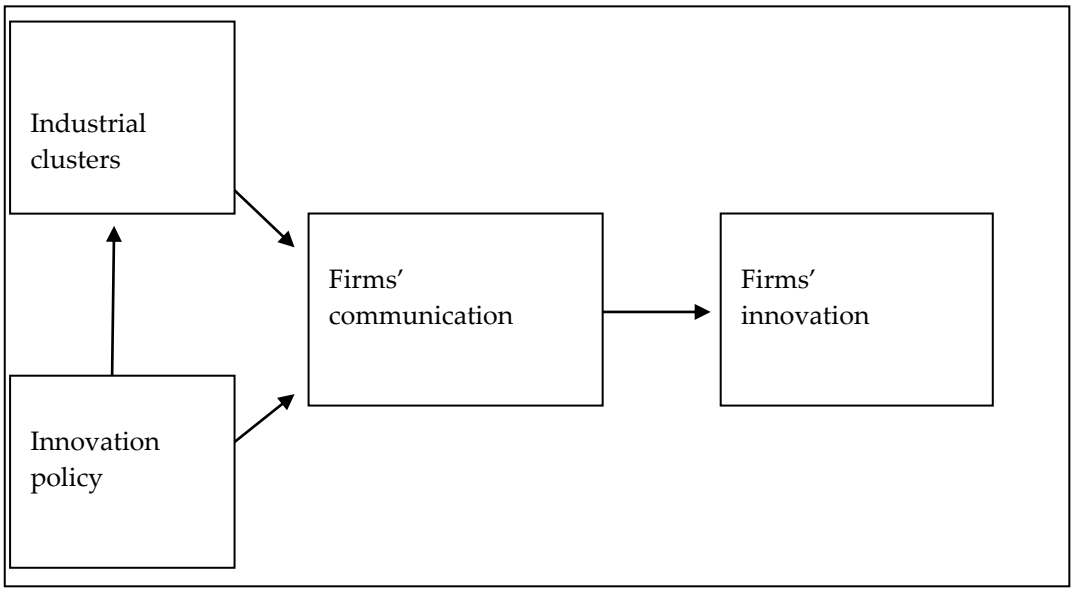
Recent studies have questioned the emphasis placed on face-to-face and buzz in explaining industrial cluster success. For example, a study on the R&D expenditure of Dutch firms

concluded that geographic proximity only explained knowledge spillovers when the knowledge related to technology from universities (Beugelsdijk & Cornet, 2002). This is because new knowledge breakthroughs often involve a wide range of actors and are not possible without interorganisational learning (Powell, et al., 1996). The ability for any one cluster to provide firms with all of the resources for innovation in one physical location is unrealistic. In fact, knowledge resources are increasingly located across multiple geographic regions (Moodysson & Jonsson, 2007). Even some of the exemplary clusters cited often in the literature, such as Silicon Valley and the Boston Biotechnology community, have established social networks that extend beyond their local environment (Baptista, 1998; Owen-Smith & Powell, 2004).

Pipeline communication channels (pipelines) refer to extra-local linkages that are important for knowledge prospecting with non-local actors (Bathelt, et al., 2004). Pipelines provide strategically focussed extra-local linkages to non-incremental knowledge flows and access to information not available within the cluster (Asheim, Coenen et al. 2007). Increasingly firms need access to expertise that is scattered throughout the world (Lorentzen, 2007). For example, Gertler and Levitte's (2005) survey of Canadian biotechnology firms found firms whose extra-local pipelines involved European collaborators or US had 11% higher innovation rates than firms with local collaborators only. Furthermore, studies of UK biotechnology clusters showed that successful firms reach out for knowledge and resources they could not find locally (Philip Cooke, 2001). However, participation in pipelines is not free or automatic. It requires firms to have a mix of common and unique knowledge that can used in interorganisational collaborations (Nooteboom, 2000).

This section has established that industrial clusters, which create geographic proximity among co-located organisations, and innovation policy, are likely to influence firms' knowledge processes. However, since firms' knowledge processes are difficult to operationalise, firms' communication channel use provides an instrument for studying firms' knowledge processes. Based this, the expected relationships between industrial clusters, innovation policy, and firms' communication channel use for innovation is presented in the research model in Figure 7.1.

**Figure 7.1 Research model**




## 7.3 Research approach

In this section, I outline the research design used to operationalise the research model. To understand influences on firms' knowledge processes for innovation a multi-level research design was required to explore the interactions between national-level innovation policy, regional-level industrial clusters, and firm-level communication channel use. It was also necessary to choose a research approach that captures the complexity and history of the innovation system. An embedded study research approach was considered to meet these requirements. Decisions regarding the embedded case study and descriptions the industrial cluster, the innovation policy, and, the biotechnology firms are presented next.

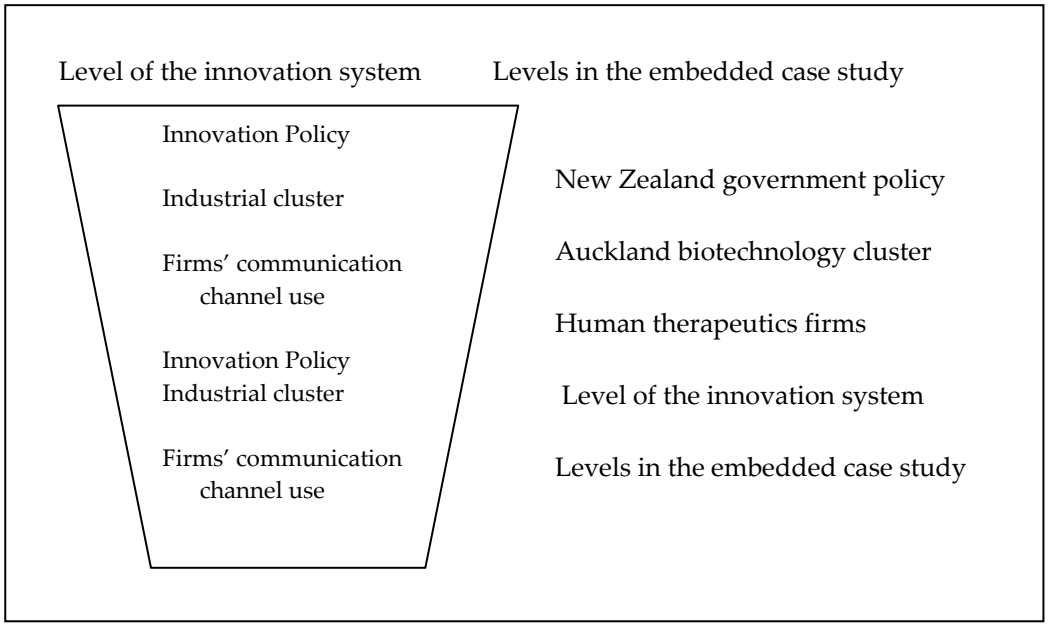
### 7.3.1 Embedded case study

An embedded case study was a suitable research approach for two reasons. First, by identifying sub-units an embedded case allows for a more detailed level of inquiry (Yin, 1994). In this study, close examination can capture firms' communication channel use in the context of the industrial cluster and innovation policy. Second, case study research can capture thick descriptions of phenomenon by using multiple sources of evidence (Yin, 1994).This is

especially appropriate for innovation research because the complexity and history of the innovation system can be taken into account.

Having established an embedded case study as a suitable research approach, it was necessary to identify an empirical setting where biotechnology firms were operating in an industrial cluster and, innovation policy initiatives had been undertaken (see Figure 7.2). My embedded case study used a typical case sampling approach (Patton, 1980) to identify a biotechnology cluster in Auckland, New Zealand where innovation policy was used to facilitate cluster growth and firms' knowledge processes. Then, selecting for theoretically relevant cases (Eisenhardt, 1989), I identified three biotechnology firms that specialised in human therapeutics and required a range of scientific and commercial expertise for their innovation process.

**Figure 7.2: Levels of the Innovation System**




## 7.3.2 Data collection and analysis

Three types of data were collected for the study. An historical description of the Auckland biotechnology cluster was constructed using first-hand accounts written by some of its members, interviews with select industry representatives, and, information collected from the local print media, government reports, and industry publications. Data collected about the

industrial cluster covered the period from the establishment of Auckland's first human therapeutics firm in 1994 until December 2007.

Information about innovation policy was collected from government publications, press releases from politicians, and policy reviews that were publically available. Data about innovation policy was collected to cover a similar period as the industrial case description (i.e.: 1996-2006). Data about firms' communication channel use was collected from interviews with firms' managers, publically available information about the firms, and presentations by firms' representatives at industry events.

While construction of the embedded case study was partly retrospective, the cluster communication channels outlined in the prior section provide a as a heuristic for describing and reporting firms' knowledge processes for innovation.

### 7.3.3 Auckland Industrial biotechnology cluster

Auckland offers a number of knowledge infrastructure inputs that are associated with biotechnology clusters. As New Zealand's largest city, three of the country's eight state-funded universities are based, or have large campuses, in Auckland. The University of Auckland, New Zealand's largest university, and AUT, its newest, are both based in the city's central business district. Auckland also hosts a profitable technology transfer office at the country's largest university.

Auckland is also New Zealand's commercial centre with a number of professional service firms providing accountancy, management consultancy and legal services. Other characteristics that make Auckland an attractive biotechnology cluster are the three research hospitals and two public science organisations that employ scientists with international research reputations.

### 7.3.4 New Zealand Innovation policy

In this section I describe the innovation policy used in New Zealand from 1994-2007. Innovation policy was informed by three policy areas. I describe the contribution of each area.

### 7.3.4.1 Research, Science & Technology

Prior to 2000, RS&T policy was primarily aimed at funding basic and applied science. In 2002 the New Zealand government announced major changes to public good R&D funding and their intention to implement a number of RS&T initiatives to stimulate knowledge processes (New Zealand Office of the Prime Minister, 2002). RS&T funding was divided into different target areas and allocated through three investment agents.

To stimulate knowledge sharing a series of stakeholder taskforces were convened during 2002. These taskforces facilitated discussion among stakeholders about industry needs with the intent of articulating strategies for sector-specific development The outcome of each taskforce was an industry-specific strategy that documented the actions required to build core competencies and critical mass (New Zealand Office of the Prime Minister, 2002).

To bridge the gap between new knowledge production and development of products for commercialization, a third scheme, the PreSeed Accelerator Fund (PreSeed), was launched in 2003  The role of the PreSeed Fund was to support the development of early-stage technology to a point where investors were interested in the commercialization potential. Around the same time, investments were increased for two existing research funds, namely the Marsden Fund and Health Research Council (Technoplis/WebResearch, 2004).

### 7.3.4.2 Industry & Economic Development

I&ED policies provided a number of instruments for supporting firm-, industry- and regional- level development. These instruments were concerned with stimulating "industry good activities". Industry good activities referred to activities that would directly and indirectly support increased firm performance and improve the business environment (Ministry of Economic Development, 2006c).With multifaceted programmes and services, I&ED policies were organised into five categories administered through two agencies. Of interest in this study were the firm- and sector- development programmes and services concerned with knowledge production and sharing in the life sciences.

Firm-development programmes aimed to make business support and business education more accessible particularly for the Small to Medium Sized Enterprises (SMEs) that dominate New Zealand's economic landscape (Ministry of Economic Development, 2006b). New Zealand Trade and Enterprise (NZTE) was established as a "one stop shop" that offered a range of products and services and was responsible for administering a number of instruments, which are summarised next (Ministry of Economic Development, 2005)..

There was recognition that firms could not always afford to access the expertise required. In addition the required expertise was not always available locally (Ministry of Economic Development, 2006b). For these reasons Enterprise Development Grants were established in 2003 to assist firms with accessing the expertise required to advanced firms' innovation (Hodgson, 2003).

New Zealand's size and remoteness to trading partners were identified as important issues for business development. This was especially important for firms in sectors that operated in international markets, including biotechnology. A range of instruments was developed to support high-growth firms in response to this need.

As well as management capability issues, a key challenge was an undeveloped venture capital market. The lack of a capital market meant that local equity was rare and networks to international capital markets were weak. Consequently, growth was stifled. Two major instruments we established to address this. In 2001, the New Zealand Venture Investment Fund (NZVIF) was launched with the aim to accelerating the development at New Zealand's venture capital market through 33% co-investment with private sector. Then, in 2005, the Seed Co-investment Fund was launched to support investment in high-risk opportunities.

Sector development programmes and services were more focussed than firm development ones. This was due to the government's approach of identifying and targeting nine sectors that it saw as providing an important role in New Zealand's future economic prosperity. A first set of sector-specific instruments focussed on identifying and addressing barriers and opportunities in those sectors (Ministry of Economic Development, 2006a).

A second set of instruments focussed on implementing activities in response to the opportunities and barriers identified. This included the establishment in 2002-2003 of the GIF Taskforces, Industry Governed Bodies Fund, and, Sector Project Fund to develop sector strategies and support their implementation through the employment of group facilitators

and provision of financial contribution for networking and related activities (Ministry of Economic Development, 2006c).

The third sector development instrument that was the creation of the Australia New Zealand Biotechnology Partnership Fund. The fund encouraged collaborative projects for new knowledge production and knowledge sharing through collaborative trans-Tasman projects, market-oriented projects, and, people and skills development.

### 7.3.4.3 Tertiary Education

The third area of public policy that provided important input to stimulating communication channels for knowledge production and knowledge sharing was education. New Zealand universities accounted for 42% of New Zealand R&D growth during 1994-2004 but during that period the government's focus changed. General University Funding reduced from 38% of total university sector R&D funding in 1994 to 26.7% in 2004. At the same time targeted funding increased from 22% in 1994 to 37.2% in 2004 (Ministry of Research Science and Technology, 2006).

The increasing role of education policy for economic growth was acknowledged in the GIF and was formalised in 2003 through the separation of post-secondary school education into an independent unit, the Tertiary Education Commission (TEC)(New Zealand Office of the Prime Minister, 2002). These structural and funding shifts represented a change in policy direction towards targeted and performance based R&D funding that was in line with the government's agenda for a knowledge society (Maharey, 2002). Given this, an examination of the Strategic Development Fund and Performance Based Research Fund provides insights into policy instruments aimed at new knowledge production and sharing.

Industry taskforces in 2001 had identified skills shortages and a lack of local expertise as critical economic issues. In response, the Strategic Development Fund was established. It delivered two schemes that directly contributed towards human capability building. These were the Partnerships for Excellence and Growth and Innovation Pilot Initiatives (GIPI) both of which sought to strengthen linkages between public sector and industry through co-funding.(Maharey, 2003). In response to biotechnology needs the Partnerships for Excellence Scheme funded two research centres: *The Maurice Wilkin's Centre for Molecular Biodiscovery* and *Institute for Innovation in Biotechnology* (Tertiary Education Commission, 2002). Similar

industry-focussed projects were implemented as GIPIs. These included enterprise training in biotechnology discovery, a bioscience community of practice, and, bioengineering innovation projects in Auckland (Tertiary Education Commission, 2002).

Focus on research excellence was also carried out through into a Performance Based Research Fund (PBRF) scheme that measured and rewarded basic research outputs of universities (Maharey, 2002). The aims of the PBRF were multiple including increasing the average quality of research and the consolidating research strengths in the tertiary education sector (Tertiary Education Commission, 2004).

## 7.4 Findings: Firms' communication channel use

In this section, I present findings about firms' communication channel use. These are presented using Bathelt et al's (2004) cluster communication channels as a heuristic of understanding firms' knowledge processes.

### 7.4.1 Face-to-face

Two features characterised firms' use of face-to-face communication channels. These were the need to transmit tacit knowledge and the need to establish relations among actors as a prerequisite for further knowledge production and knowledge sharing activities.

New knowledge creation is characterised by high levels of uncertainty so firms used face-to-face communication to transfer scientific knowledge associated with interpreting findings, solving problems and understanding how new knowledge relates to what was already known. This was especially common when firms were involved in basic science and proof-of-concept R&D activities. Face-to-face was often used for sharing information among public science organisations and firms:

> "We run a lot of commercial contracts here for other groups as well through our university's commercialisation arm. Therefore, we have been very clear from the beginning that information is not compartmentalised. I mean we have a meeting every week where people [working in the research centre] tell you what they do. It doesn't

matter what they're working on, a commercial contract or a public grant – 'I'm doing this, I'm thinking of doing this, this is why I'm doing it'" (Head of a Public Research Organisation, interview, 2007).

Face-to-face was also used by some start-up firms to share their experiences:

"We talk together; we will go to NZBio functions and say "how is it going and what's happening?". I wouldn't say I had an in-depth knowledge of their science. They only tell me stuff they want to, but most of them I talk to quite a lot. GC [founder of another biotechnology firm] has always been someone I can go and talk to. So occasionally when I have problems I go down and talk to GC. He wouldn't give me the answer, he wouldn't know the answer necessarily, but he would at least give you the feeling that he'd been there. He'd done it too, you know he'd say "hang in there" give you a little bit of encouragement" (Firm Founder, interview, 2007).

The second feature of face-to-face communication was its use in establishing relations for future knowledge processes. Knowledge-sharing requires a degree of trust that one actor has the competence to be able to accurately value the knowledge the other actor holds (Das & Teng, 1998) and face-to-face was used in determining this. In regards to visiting potential contract research organisations:

"We've got their proposals; we know how much they're proposing to charge. And we've got an idea of their experience. The next step is going over there and seeing what they're like in person and whether we can work with them. What they say is the main thing; whether they're talking the same language that they understand the clinical research and what we need as a company" (Clinical Project Manager, interview, 2008).

Firms often used face-to-face to scan third parties to assess if there was a degree of research commonality worth pursuing. For example,

"He [the collaborator] did a PhD and our stuff [the firm's research] got discussed. He just asked to have a chat with me at a little conference. So he came [and talked] to me [at the conference] and he said 'okay, we're interested in this [the firm's research]. We're studying epilepsy and looking at da, da, da; your product would help us'. So, from that

we then put together an application and it went from there." (Firm Founder, interview, 2007).

### 7.4.2 Pipelines

Pipelines were essential for accessing different types of resources that were not available within the cluster. Firms required access to extra-local venture capital because New Zealand has a young venture capital market with limited experience of investing in the life sciences. Venture capital was important because established venture capital markets and experienced investors have been identified as antecedents of successful biotechnology start-ups (Baum, et al., 2000; Powell, et al., 2002).

> "The firm spent some time attempting to raise capital to develop the drug in New Zealand, and it's not easy in New Zealand, because capital tends to small. It tends to be relatively low risk in the pharmaceutical industry, because we're still a new industry and so it's an expensive capital… in the end we went to the United States, partly because we had an opportunity to do a [investment] deal with large pharmaceutical company" (Firm Founder, interview 2007).

An important stage in the R&D process of human therapeutics is the safety of compound use in animals, referred to as pre-clinical trials. Testing compounds in animal biological models is a required method for reducing potential harm when testing in humans. Potential animal models exist throughout the world and pipeline communication channels provide extra-local linkages to those organisations who sought to test their compounds.

> "I've got the [American] University doing work in one of our compounds on a muscle wasting disease. So they've got this model of disease in animals and they want to try our compound because they've read our [peer reviewed journal] papers. And they just rang up one day and got chatting, so they're doing it now [testing the firm's compound in the University's animal model]" (Firm CEO, interview, 2007).

Preparing and implementing clinical trials requires expertise from a number of specialised knowledge domains. Pipelines were used to access knowledge domains that were not available in the cluster:

> "We have a number of consultants in the United States … we have one consultant, for example, who is a specialist in our area with the FDA. So she's assisting with all our IND work for the FDA." (Firm Founder, interview 2007)

The consultant's scientific expertise provided both discipline knowledge and regulatory knowledge. In addition, the consultant was US based and was able to seek informal face-to-face meetings with FDA regulatory officials at substantially less cost than the firm could.

Some firms in the HT cluster viewed it as unrealistic to locate all the expertise required for their innovation process in one geographic location and they saw building and using pipelines as a necessary part of their business:

> "There's a whole lot of questions that need to be answered as you go into clinical trials. .. one thing for example is … we need someone to formulate and package a cold gel. We suddenly find that there's no one out there who can do GMP [good manufacturing practice] cold formulation … so we now have to look at re-formulating the gel so that it can be made and packaged under GMP conditions. But that means going back and re-doing some of your experiments to make sure that the new formulation is working as effectively as the previous one. All those questions pop up all the time and if you just say 'okay we're going to move drug develop to the United States', you've got one scientist in New Zealand, and one in the UK, moving to the US isn't always the easiest way to do it" (Firm Founder, interview, 2007).

Pipelines were enhanced through occasional face-to-face. This created temporary geographic proximity for information exchange over a certain period of time (Torre, 2008). The following quotes illustrate the extent to which employees would travel to in order to maintain extra-local relations:

> "Much of this is about personal relationships and, well it's actually all about personal relationships. If you don't know and trust the person then you won't be able to work with them which is, well it's critical. Our Chief Science Officer is on a plane on Sunday and he's back on Saturday. He's going to the US and Canada because we need to

maintain those personal relationships and get them here. The Russians came out here a month ago and that's because they understand that they need to maintain that relationship" (CEO Firm, interview, 2007).

"I probably go away every month to six weeks and a trip can be a week to two weeks. But our CEO is here probably 50/50 [percentage of his time]" (Firm COO, interview, 2008).

The need for occasional face-to-face also depended on the stage of the R&D process. Firms used face-to-face communication more when venture capital funding rounds were launched, new intellectual property was disclosed, clinical trials were launched, and, when trials came to an end. Actors were willing to travel to create temporary geographic proximity when they felt that knowledge production at a certain stage of the R&D process required it.

"Somebody from our firm goes to Europe every 1 to 2 months. At this stage we deliver [physically courier] the product personally and also supervise the implants [of the product into the patient by the contracted clinical trial researcher], it's [delivery and supervision] not necessary in the future, but while the trials are early we continue to do that" (Firm CEO, interview, 2008).

### 7.4.3 Buzz

Similar to other studies on the production and sharing of scientific knowledge (Asheim, et al., 2007) buzz was the least used communication channel. Nonetheless, it was used for sharing information about general developments in the industry and within the cluster. Buzz communication channels can create a perception of increased activity within a cluster (Bathelt, et al., 2004) and this was also identified by the firms:

"I think it's [the creation of NZBio, the industry stakeholder organisations] having a major effect, I think it's brilliant. Because they have regular functions where people do come together and sit and talk. So I think it's very important" (Firm founder, 2007).

To summarise section 7.4, the experience of firms in the Auckland biotechnology cluster confirms existing studies of biotechnology cluster communication. Firms rely on face-to-face

and pipelines because these best support the knowledge processes that enable firms' innovation requirements.

## 7.5 Do industrial clusters and innovation policy influence firms' communication channel use?

In this section, I identify and discuss firms' communication channel use in response to industrial cluster and innovation policy influences. Policies oriented towards disciplinary knowledge production most commonly stimulated face-to-face and pipeline channels. In New Zealand, this was achieved primarily by funding and/or subsidizing the R&D costs for biotechnology firms. To encourage clustering activity policy initiatives required collaborative arrangements among public and private organisations. These arrangements varied from straightforward contract research, such as running assays, to substantial research programs that produced shared intellectual property. Overall, the effect was to encourage collaboration among co-located organisations, thus reinforce clustering effects.

Coordinating with colleagues on complex research activities used face-to-face communication. This was supported through policies that paid for the employment of scientists into the firms and attracting postgraduate research students to work on parts of these projects. Face-to-face was perceived as necessary for a number of reasons. Firms were to be able to train new staff, ensure fast feedback among the team, and, maintain oversight of commercially sensitive activities.

To increase face-to-face communication some firms also chose to locate their facilities within the research universities. Other firms chose locations that were close to universities. Firms did not receive direct support from government for re-location; however, *The Centres for Excellence s*cheme funded the establishment of three research centres at Auckland's main research university. Through these centres, firms co-located in the buildings or rented research facilities within these research centres on a short-term basis. Both of these practices gave firms ongoing face-to-face communication with public scientists.

Firms within the cluster also needed expertise that was not available locally. Instruments oriented towards disciplinary knowledge production were able to support pipelines because

they provided resources that could be used to search and screen for potential collaborators. In addition, small amounts of funding gave firms resources that they used to create temporary geographic proximity (Torre, 2008) with the organisations they needed to collaborate with.

Firms' required business knowledge as well as disciplinary knowledge. This was necessary as it provided commercial understanding of how in the New Zealand context disciplinary knowledge could be commercialised. During this period there was increasing academic and popular literature on biotechnology commercialisation but these had to be adapted to fit the specifics of the New Zealand innovation system. These specifics included the immature local venture capital market and the shortage of commercialisation expertise (Beckman & Goldberg, 2003).

General business development policies were less successful at supporting business knowledge production and there seems to be two main reasons for this. First, I&ED policies were predominantly concerned with developing SMES and biotechnology firms were just one of a number sectors identified for policy attention. Secondly, there was limited business expertise in the biotechnology cluster that meant there was few people firms could learn. Thirdly, I&ED funding was substantially less than funding committed to RS&T; signalling that knowledge commercialisation was less important than knowledge production.

The second policy category was concerned with increasing knowledge sharing associated with research and development. Unlike the instruments used to create the conditions for knowledge production, most of the knowledge-sharing stimulus tools were new. This included facilitation of industry taskforces and stakeholder organisation by RS&T and I&ED agencies, schemes to encourage networking into key markets (e.g. Enterprise Development Grants, Growth Services Fund, Sector Services Fund), and, development of local seed- and venture capital markets. These policies were effective at creating buzz in the industry.

To facilitate connections among members NZBio established six regional offices, including one in Auckland. One aim of the regional chapters was to collectivise the interests of individuals and organisations operating in biotechnology in order to progress industry development efforts. Regular networking events were scheduled where members could meet one another to achieve this. Organisations that were willing to sponsor networking events had the opportunity to profile their work through presentations at these events. While these

initiatives were useful in raising the profile of the cluster, firms did not report the use of buzz in their innovation.

A range of activities provided industry-building opportunities for firms to develop their communication pipelines. However, NZBio firms' pipelines were extended thought contact with non-local organisations interested in firms' activities. Firms also developed their pipelines through representation at annual conferences in New Zealand, Australia and North America. Participation at these events was coordinated by NZBio and subsided by government.

## 7.6. Conclusion

This study set out to investigate the effects that industrial clusters and innovation policy have on biotechnology firms' knowledge processes for innovation. Given that knowledge processes can be difficult to discern until they become obvious (Patriotta, 2003) firms' knowledge processes were conceptualised as communication channel use. By examining firms' communication channels for innovation the affect of industrial clusters and innovation policy influence was examined.

This study was important because much scholarship has concentrated on developing innovation policy, while less attention has been paid to evaluating policy affects (B. Lundvall & Borras, 2005). Through an embedded case study, this study offers new insights into the affects of industrial clusters and innovation policy on biotechnology firms' communication channel use.

Literature shows that knowledge related to biotechnology increasingly extends beyond local networks. Therefore, it is important that cluster development policies reflect the state of the industry. The study confirms that policy instruments can stimulate firms' communication channels. However, it is not always clear that firms' innovation is influenced by the communication channels stimulated

The study found that buzz was the least effective communication channel for facilitating innovation. In contrast, pipelines were critically to providing access to expertise. These findings support Asheim et al's (2007) argument that in biotechnology firms buzz is the least

important communication channel. Together these studies raise questions about the limited relevance of innovation policy designed to facilitate buzz.

The findings about firms' communication use have important implications for politicians and innovation policy makers. Based on the experience of these firms, innovation policy is likely to be more effective when it is focussed towards facilitating firms' face-to-face and/or through pipelines.

# 8 STUDY - 3: SEARCHING NEAR AND FAR: A PRACTICE PERSPECTIVE OF KNOWLEDGE ACCESS IN EMERGING CLUSTERS[2]

Abstract: Search practices for accessing external knowledge are widely recognised as crucial for innovation. Geographic proximity, industrial clusters and relational proximity are argued as providing suitable conditions for searching, especially given the context/situation dependence of search practices. However, their influence on searching in emerging clusters requires elaboration. Taking the practice perspective, this study explores how geographic proximity, cluster life-stage and relational proximity influence search practices. Agents' practices from an emerging biotechnology cluster are compared to practices from existing clusters. Experience-based differences in agents' practices are theorised as Regulars and Strangers in cultural fields. Implications for cluster life-stage and relational proximity research, and public policy regarding cluster management are considered.

Keywords: emerging industrial clusters; biotechnology; knowledge access; practice; situated learning, knowledge search.

Search practices for accessing external knowledge are widely recognised as crucial for innovation (De Clercq & Dimov, 2008; R. Grant & Baden-Fuller, 2004; Katila & Ahuja, 2002;

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[2] L.Callagher (forthcoming) Searching near and far: a practice perspective of knowledge access in emerging clusters *International Journal of Entrepreneurship and Innovation Management*

Powell, et al., 2005). However, search practices are strongly situation dependent (Broekel & Binder, 2007) making their transferability across contexts problematic. This paper explores how search practices for knowledge access are influenced by geographic proximity, cluster life-stage and relational proximity.

Search practices are the arrays of problem-solving activities (Katila & Ahuja, 2002) undertaken as part of the knowledge access process (R. Grant & Baden-Fuller, 2004). Central to knowledge access are the learning conditions that influence it (Barringer & Harrison, 2000; Easterby-Smith, et al., 2008; Hagedoorn, 2002).

My review of the literature highlights that geographic proximity among knowledge-based firms, universities and specialised business services is a common condition for interorganisational learning. This is because industrial clustering provides a knowledge infrastructure that is fundamental to developing and commercialising firms' new technologies (Bresnahan, et al., 2001; Casper, 2007; Dorfman, 1983; Myint, et al., 2005; Powell, et al., 2002; Powell, et al., 2005; Saxenian, 1994; Swann, et al., 1998). Despite what is known about industrial clustering and interorganisational learning, the influence of cluster life-cycle has rarely been taken into account (Baptista, 1998; Menzel & Fornahl, 2010). This is intriguing given that studies of cluster success (Saxenian, 1994; Swann, et al., 1998) and failure (Orsenigo, 2001) suggest that clusters follow their own life cycles with stages of emergence, growth and decline that do not follow industry — or firm- life cycles (Menzel & Fornahl, 2010; Pouder & St. John, 1996; St John & Pouder, 2006).

Relational proximity is also an important condition for interorganisational learning because similarity among organisations in regards to norms, values, and rules of thought and action aide in establishing common understandings about 'how and why' things are done (Amin & Roberts, 2008; Coenen, et al., 2004; Lechner & Dowling, 2003). Relational proximity is especially important considering the context and situation dependent aspects of search practices (Broekel & Binder, 2007).

In order to understand the influence of cluster-life stage on knowledge access, the search practices used at biotechnology firms operating in an emergent cluster in New Zealand will be compared to the search practices reported in the literature on established clusters. To understand the influence of geographic and relational proximity on knowledge access, the search practices used under close and distant proximities are compared. The ways that search

practices are influenced provides the basis for a discussion about the impact of agents' experience on knowledge access in emergent clusters. While the purpose in this paper is to develop exploratory insights only, I will offer some initial empirical evidence in support of recent calls for greater consideration of cluster life-stage. I will also argue that agents' practices provide a useful means of understanding how proximities influence knowledge access.

## 8.1 Background Theory

External knowledge is increasingly important for innovation. Few firms can maintain more than a handful of core competencies — they must focus on what they are good at (Hamel, 1991). For example, in biotechnology, the expertise required to commercialise molecular biological ideas cannot be achieved by single organisations (Powell & Brantley, 1992).

At the same time, user-centred innovation (von Hippel, 2005) and the addition of external expertise through open innovation (Chesbrough, 2003; Chesbrough, Vanhaverbeke, & West, 2006) present opportunities to create new and increasingly complex products for the market (J. Tidd, et al., 2005) and find new ways to capture value (Chesbrough, 2003). Thus, firms face the challenges of balancing the need to protect their own knowledge bases and of developing new products through new knowledge combinations.

Knowledge access — the process of exploiting knowledge from a partner's knowledge domain to the firm's products with the intention of maintaining the distinctive knowledge bases of both firms (R. Grant & Baden-Fuller, 2004) — provides a way of doing this. Grant and Baden-Fuller (2004) proposed that knowledge access be understood as a five-phase process of search, selection, coordination, integration and exploitation. First, the firm must search for potential partners who have the desired knowledge, and from potential candidates select firms to partner with. Next, coordination mechanisms are required for the integration of its partner's knowledge with the firm's product development. Finally, exploitation must enable the firm to make improved use of its own knowledge assets by exploiting the knowledge gained from its partner.

While Grant and Baden-Fuller's (2004) theory explains interorganisational learning and innovation as a linear knowledge access process, Broekel and Binder (2007) argue that the activities involved in searching are strongly context and situation dependent and are difficult to describe for all situations. Davenport's (2005) study demonstrating the variety of local and non-local knowledge acquisition activities used in small and medium sized enterprises' innovation processes illustrates Broekel and Binder's (2007) point. Similarly, on reporting their study of collaboration in biotechnology, Powell et al (2005 p. 1183) concluded that "the process of searching for partners is both dynamic and recursive". These works suggest that knowledge access by firms is in reality likely to be more 'messy' than Grant and Baden-Fuller's (2004) normative model proposes, and that closer exploration of the actual practices that individuals undertake as they search out knowledge is likely to provide a more nuanced understanding of knowledge access.

### 8.1.1 Practice perspective on search

Theories of practice provide a useful lens for exploring the activities that individuals use during the search phase of knowledge access. A practice view has been used in a number of recent empirical studies of organisational learning (Gherardi, 2009a; Nicolini, 2007; Nicolini, Gherardi, & Yanow, 2003), and has been proposed as a way of understanding innovation processes (Carlile, 2004 ; Crossan & Apaydin, 2010). A practice perspective views learning as the practices that individuals 'carry' and 'carry out'(Reckwitz, 2002) . From this perspective, knowledge is embodied in the minds and bodies of individuals and in the objects that they use (Carlile, 2004; T. Schatzki, 1996). Thus, knowledge access occurs when individuals from different organisations interact with each other and with objects, as they carry out their work. Although there is no single and agreed theory of practice, 'practices', 'agents' and 'objects' are agreed concepts that provide a heuristic for seeing and analysing social phenomena (Reckwitz, 2002) such as knowledge access. Practices are arrays of activities that involve a number of interconnected elements. These elements include "un-reflexive reactions, actions, utterances, linguistic acts, behaviours, routines" (Nicolini, 2007 p. 892) and objects that acquire meaning when in use (Reckwitz, 2002; 1996, 2002). A practice can consist of these elements but cannot be reduced to any of them.

Practices are also forms of situated action (Suchman, 1987) or situated learning (Lave & Wenger, 1991) and the understandings imbued in them depends upon the cultural field (Bourdieu & Wacquant, 1992) in which they are carried out. Cultural field refers to the setting in which agents are located. Cultural fields are social spaces and structures that regulate agents' practices within them. Structures are dominant schemas that represent legitimised and accepted ways of knowing (the mind) and ways of acting (the body) within a cultural field (Bourdieu, 2005). Thus, from a practice perspective, 'search practices' are patterns of activities that when produced and reproduced are understandable to the agents who carry them out and to those who observe them within a cultural field.

Agents are defined as the 'minds and bodies' who carry and carry out practices. Viewing the body as part of a practice is central because routinised behavioural acts are physical and mental performances. Bodily performances of practices are observable and provide a social order within a cultural field. Hence, the bodily actions of the agent are central to a practice. At the same time, practices are mental activities. Mental actions imply routinised ways of understanding the world and knowing how to do something. Finally, objects are a necessary component of a practice theory because practices often involve using particular objects in a certain way (T. Schatzki, 2002) . Objects, (e.g.: telecommunication devices) mould practices because they can enable or limit mental and bodily practices. Taken together 'practices', 'agents' and 'objects' offer a conceptual framework for understanding the search phase of knowledge access.

Search can be defined as "the problem-solving activities that involve the creation and re-combination of technological ideas" (Katila & Ahuja, 2002 p. 1184). Search is necessary when the firm's knowledge domain is insufficient to perform particular activities successfully (De Clercq & Dimov, 2008). The firm's knowledge domain represents a cultural field so when practices within the firm are not sufficient to solve its problems, agents search out practices from other cultural fields — that is, other organisations — which will solve them. From a practice perspective, search can be understood through the patterns of problem-solving activities that agents exhibit when they seek practices or objects that might contribute to solving problems.

Searching involves the collecting of information that informs subsequent knowledge access phases. This includes information about the complementary skills that potential partners can

offer, signs that similar goals and a cooperative culture does (or could) exist between the firms, and indicators that the levels of risk vis-à-vis rewards are perceived as fair (Brouthers, et al., 1995).

From a practice perspective, complementary skills can be understood as those practices from a different cultural field that enable the firm to develop its products. Because of the situated nature of practices, the meanings and understandings ascribed to practices differ across cultural fields. This suggests that when searching out practices from other fields, agents must consider whether sufficient meanings and understandings can be developed between them, so that the firm can exploit and apply practices that the partner provides.

Prior experience is recognised as an important factor in the search phase (Gulati, 1995; Hoang & Rothaermel, 2005). Agents with prior experience from other cultural fields can refer back to those practices when searching for new knowledge. Even when agents are searching out new practices of which they have no direct experience, their ability to identify related patterns of activities will inform their current search actions.

To summarise, a practice perspective draws attention to the situated nature of practices and the challenges this presents for agents who search out knowledge on behalf of the firm. When new practices are required to advance the firm's products, its agents must be able to search out practices across different cultural fields. Given that search requires the broaching of different cultural fields, influence of proximity on practices requires closer consideration.

## 8.2 Proximity as an influence on search practices.

In their review of proximity and interorganisational collaboration, Knoben and Oerlemans (2006) identified that the concept of proximity is used on a number of dimensions. To understand the influences that proximity has on search practices, two dimensions appear to be pertinent. These are geographic and relational proximity. Geographic proximity and interorganisational learning are of particular interest in industrial cluster research. The learning advantages offered by clustering are demonstrated by numerous studies and these are particularly prevalent amongst biotechnology firms. However, clusters vary in the localised learning opportunities they can offer at different stages of their life-cycles. Hence,

my aim in this section is to consider geographic proximity, cluster life-stage and relational proximity as influences on search practices for knowledge access.

### 8.2.1 Geographic proximity.

Boschma (2005 p. 69) defines geographic proximity as the "close spatial or physical distance between economic actors both in its absolute and relative sense". Geographic proximity is argued to be an important factor in interorganisational learning because of the tacit aspects of knowledge that make it 'sticky' and hard to share without physical contact (Howells, 2002; Szulanski, 1996; von Hippel, 1994). Small geographic distances facilitate planned and unplanned face-to-face interactions that support efficient knowledge sharing and innovation (Knoben & Oerlemans, 2006).

In recognising the importance of geographic proximity as a means of facilitating interorganisational learning, industrial clustering is often proposed as an organising mode that provides spatially based conditions for learning and innovation (Krugman, 1991; Malmberg & Maskell, 2006; Porter, 1998). Extant literature about established and well-known knowledge-based clusters offers insights into common search practices used by technology firms (Bresnahan, et al., 2001; Casper, 2007; Dorfman, 1983; Myint, et al., 2005; Powell, et al., 2002; Powell, et al., 2005; Saxenian, 1994; Swann, et al., 1998) (A summary of these practices is provided in Figure 8.1).

The first of these search practices relates to technology firms clustering around public science organisations such as universities, to use them as sources of technology and skilled labour. Universities often licence out their new concepts, and geographically proximate firms are likely to hear about new opportunities before their non-local competitors (Bresnahan, et al., 2001; Chiaroni & Chiesa, 2006; Powell, et al., 2005).

Clustering around universities is particularly important when embedded knowledge is considered. Most universities' new technologies are proofs of concept only and require considerable development before they can be commercialised (Jensen & Thursby, 2001). However, some knowledge required to efficiently advance inventors' discoveries remains latent because inventors cannot articulate everything that they know (Agrawal, 2006). Firms which access inventors' knowledge gain insights that can inform ongoing development and increase the likelihood of commercial success (Agrawal, 2006). While firms that are not

geographically close can still engage with inventors, clustering provides the opportunity for this type of commitment in a cost- and time-effective manner.

**Figure 8.1: Firms' search activities reported in literature on established clusters.**

| Search activities: | Studies: |
|---|---|
| Licensing university discoveries | Bresnahan et al, 2001<br>Owen-Smith and Powell, 2004<br>Chiaroni and Chiesa, 2006 |
| Communicating with inventors | Agrawal, 2006 |
| Communicating and working with public scientists and the local labour pool | Saxenian, 1994<br>Powell et al, 1996<br>Bresnahan et al, 2001<br>Myint et al, 2005<br>Chiaroni and Chiesa, 2006 |
| Building personal ties through entrepreneurial and spin-off activities | Saxenian, 1994<br>Myint et al, 2005 |
| Meeting venture capitalists formally and informally | Dorfman, 1983<br>Powell et al, 2002 |
| Identifying existing regulatory, manufacturing and marketing activities in other industries. | Owen-Smith and Powell, 2004<br>Dorfman, 1983<br>Bresnahan et al, 2001 |
| Extra-local networking | Owen-Smith and Powell, 2004 |

Clustering around universities also provides ease of access to specialised labour. Technology firms often face complex problems whose solutions require knowledge from multiple fields of expertise. At the same, resource constraints and uncertainty about future technology requirements make it difficult for firms to rely exclusively on in-house expertise (Shan, Walker, & Kogut, 1994). Clustering around universities provides a geographically convenient pool of specialised expertise from which firms can search out knowledge to solve their problems through short-term employment, contracting or interorganisational arrangements (Bresnahan, et al., 2001; Chiaroni & Chiesa, 2006; Myint, et al., 2005; Powell, et al., 1996; Saxenian, 1994).

The second common search practice relates to the clustering of technology firms and other specialised business services. Specifically these are sources of expertise that provide technological capabilities (Arora & Gambardella, 1994) and a knowledge infrastructure (Baptista, 1998) which are necessary for commercialisation.

Due to the high rates of firm failure associated with the industry, biotechnology workers often maintain peripheral involvement in multiple firms through consultancies, directorships and memberships on senior management teams. To make their multiple commitments manageable, workers often contain their activities within a close geographic proximity (Casper, 2007). As well as benefiting career management, portfolios of activities provide personal ties to geographically proximate experts for the new entrepreneurial start-ups and spin-offs who employ them (Myint, et al., 2005; Saxenian, 1994).

Venture Capital firms (VCs) are crucial to funding for technology firms. VCs' preference to maintain physically close monitoring of their investments through face-to-face interactions means that they too benefit from clustering. This provides biotechnology firms with search opportunities regarding future investments (Powell, et al., 2002). VCs also provide search opportunities regarding strategic guidance for firms with limited managerial competence (Dorfman, 1983).

The regulatory, manufacturing and marketing activities crucial to new products often go beyond the applied research expertise of technology firms (Pisano, 1991). Resolving this knowledge gap also requires searching to find solutions. This involves recognising what existing regulatory, manufacturing and marketing processes are available in other industries, adapting them to new purposes and developing new ones where required (Bresnahan, et al., 2001; Dorfman, 1983; Owen-Smith & Powell, 2004).

Despite all of their benefits, however, established clusters cannot fulfil every specialised knowledge need. Firms must nonetheless build networks or pipelines so that they can undertake extra-local searching through global networks (M. S. Gertler & Levitte, 2005; Lorentzen, 2007; Moodysson & Jonsson, 2007; Owen-Smith & Powell, 2004; van Geenhuizen, 2008).

### 8.2.2 Cluster life-stage

Although industrial clusters have attracted much attention, less concern has been shown to the influence of cluster life-stage (Swann, et al., 1998). Some researchers have linked clusters to industry life cycles (D. Audretsch & Feldman, 1996a for example) but studies of cluster success (Saxenian, 1994; Swann, et al., 1998) and failure (Orsenigo, 2001) suggest that clusters

follow their own life cycles with stages of emergence, growth and decline that do not follow industry- or firm- life cycles (Menzel & Fornahl, 2010; Pouder & St. John, 1996; St John & Pouder, 2006). Each cluster stage is characterised by differences in the number of firms, employees and the nature of the localised knowledge base (Menzel & Fornahl, 2010). From a practice perspective, these characteristics are likely to influence search practices.

Emerging clusters, which often operate in new industrial sectors such as biotechnology, are characterised by young knowledge-based firms in the early stages of development. Typically, emerging clusters will have few firms with a lasting vision for a new local technology path. They often have favourable local scientific and political conditions to support cluster growth to a critical mass, but experience a small skilled labour market due to few workers having been employed and heterogeneity of technology (Menzel & Fornahl, 2010). These characteristics culminate in weak conditions for localised searching because there are a small number of agents who share limited cultural fields. Because of this, there are few local interorganisational learning opportunities, so agents must engage in non-local searching.

In contrast, established clusters experience strong growth of existing firms and new start-ups. They have a knowledge infrastructure that includes cluster stakeholder organisations and other institutions that support their activities. Firms are oriented towards collaborating with other local firms, which in terms of technological homogeneity, makes the boundaries of the cluster more definable (Menzel & Fornahl, 2010). These characteristics provide strong conditions for localised searching because there are large numbers of agents to learn from and they stay in the local area because there are regular work opportunities. Furthermore, the increased support of various institutions provides more cultural fields to search.

Given these differences between emerging and established clusters, cluster life-stage is likely to influence search practices.

### 8.2.3 Relational proximity

Relational proximity (also referred to by some authors as social proximity) refers to the relative closeness — or distance — among actors in regards to norms, values, and rules of thought and action (Coenen, et al., 2004; Lechner & Dowling, 2003). Relational proximity research highlights that the situated nature of practices is concerned with ways of knowing,

and not only with the geography where knowing takes place (Amin & Roberts, 2008). From a practice perspective, relational proximity is important because it assists agents in recognising and valuing practices that are performed in different cultural fields. While agents cannot share exactly the same meanings, similar mental models provide common understandings about 'how and why' things are done. Common understandings make it easier for agents to recognise practices and judge whether those practices are performed in ways that will benefit the firm.

In search situations that involve specialised and expert knowledge — such as in biotechnology — close relational proximity is required to recognise the norms, values and ways of knowing related to a practice (Amin & Roberts, 2008). Through participation, agents develop mutual acquaintances and gain recognition that provides dense ties and membership to a cultural field (Nahapiet & Ghoshal, 1998) and ways of knowing in that field (Boland & Tenkasi, 1995).

Conversely, however, agents do not always need to be deeply embedded in a cultural field to recognise its practices. Granovetter's (1985) study of job search shows that in some situations distant relational proximity, or weak ties, is advantageous because it offers entry into a wider array of activities that are less likely to provide redundant information. In Granovetter's study, low relational proximity was of direct benefit as it reduced agents' potential opportunity evaluation costs.

Unruh (1979) argues that agents' participation varies depending upon their reasons for engagement. He offers a typology of strangers, tourists, regulars and insiders to locate varying levels of participation that agents can engage in, depending upon the depth of understanding required. Agents who experience close relational proximity to potential partners are described by Unruh (1979) as Regulars. Regulars are characterised by their regular and routine participation in other cultural fields. Regular participation is characterised by a degree of understanding and commitment to the values, norms and ways of knowing in those cultural fields. Through routine participation, agents are recognised as legitimate members in those fields, but not as experts or insiders. From a knowledge access perspective, it is disadvantageous for agents to be deeply embedded in multiple fields because of the effort it takes to gain entry to and maintain participation in them. Nonetheless, agents who participate

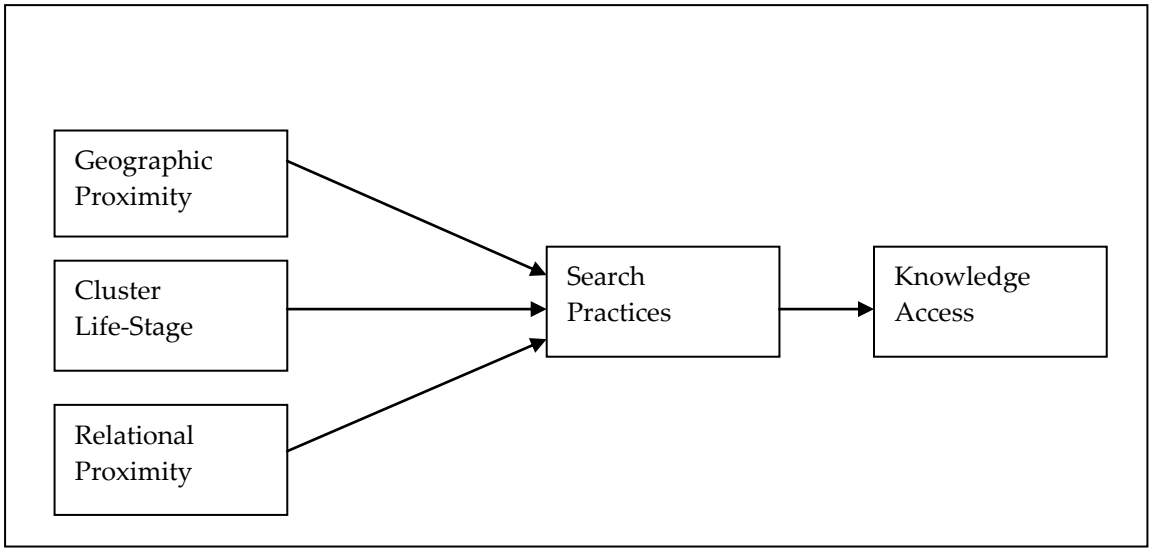
as Regulars in different cultural fields will have a wider array of practices to draw from when searching.

In contrast, Unruh best describes agents who experience distant relational proximity with potential partners as Strangers. Strangers are characterised by their lack of participation in other cultural fields. Their non-participation in other cultural fields sees them identified within them as outsiders who are indifferent to the ways of behaving and knowing that are accepted in those fields. Any relationships that are formed are superficial in nature because Strangers do not share similar values, norms and ways of knowing with their potential partners (D. Unruh, 1979). From a knowledge access perspective, it is problematic for agents to be Strangers in the fields that they search because their limited array of practices will make it harder for them to search.

## 8.3 Conceptualising influences on search practices

When search is viewed from a practice perspective, it becomes apparent that different dimensions of proximity are likely to influence the practices that agents use (see Figure 8.2). For firms operating in emerging clusters, the need for geographically distant knowledge is likely to be greater, because emerging clusters provide limited local learning opportunities, which accordingly influences agents' search practices. Relational proximity is also likely to influence agents' search practices because it defines different types of participation in cultural fields (D. Unruh, 1979). The next part of this paper presents empirical findings from an exploratory case study that supports this explanation of influences on search practices.

**Figure 8.2: Influences on Search Practices Framework**




## 8.4 Research design/method/data

Using a typical case sampling approach (Patton, 1980; Yin, 1994) I identified a research site that demonstrated the characteristics of an emerging cluster whose activities were influenced by varying geographic and relational proximity. Emerging clusters are characterised by a few firms with a lasting vision for a new local technology path. They will have experienced favourable local scientific and political conditions to support cluster growth to a critical mass (Menzel & Fornahl, 2010). I identified a biotechnology cluster specialising in human therapeutics in Auckland, New Zealand that exemplified those characteristics.

New Zealand has a long tradition of agricultural research and development (R&D) that dates back to the 1880s. Since the late 1990s, political attention has focussed on moving New Zealand towards a knowledge-based economy (Marsh, 2003). This led to substantial refocusing of public policies and investment towards high technology industries, including biotechnology (Biotechnology Taskforce, 2003; New Zealand Office of the Prime Minister, 2002).

Predominant in the biotechnology agendas of successive governments was the development of a biotechnology cluster in Auckland, New Zealand's largest city. Auckland city offered a number of knowledge infrastructure inputs for an emerging cluster. Three of the

country's eight state-funded universities are based, or have large campuses, in Auckland. The University of Auckland, New Zealand's largest university, and AUT, its newest, are both based in the city's central business district. Auckland is also New Zealand's commercial centre with a number of professional service firms providing accountancy, management consultancy and legal services. As well as providing knowledge infrastructure inputs for an emerging cluster, these organisations provide search opportunities in close geographic and relational proximity.

Other characteristics make the Auckland biotechnology cluster a suitable research site for this study. Human therapeutics is a sub-category of the biotechnology field that is concerned with the discovery and application of remedies for disease. In the early phases of drug development, biotechnology firms can rely upon the knowledge and capital resources available from local organisations, especially public science organisations. In the early phases, close relational proximity is expected because the biotechnology firms and universities share similar norms and goals regarding early-stage research exploration.

As products move into pre-clinical trials – which involve testing on animals – and Phase I and Phase II human clinical trials – involving testing on small numbers of human subjects – knowledge must be sought from a wider range of knowledge domains. Regulatory knowledge is required, as is, toxicology, chemistry, manufacturing control and monitoring expertise (Pisano, 2006a). The norms and goals that drive these types of firms are concerned with commercialisation. At the time of data collection, few firms in the cluster had direct experience of drug development beyond Phase I human clinical trials (see Appendix 1). Furthermore, there was limited regulatory, clinical research, manufacturing and marketing services available locally (Ernst&Young, 2003).

In addition, the cluster is physically isolated from other hubs of biotechnology activity. Australia, which has a number of clusters, is a three-hour international flight away, Asian destinations require at least ten-hour flights and Auckland-Los Angeles is a 12-hour one-way trip. Thus, firms operating in the Auckland cluster had some local search opportunities, but operated under conditions of distant geographic and relational proximity in respect of the knowledge needed for significant areas of their operations.

Having identified a cluster that exhibited the characteristics under investigation, my next step was to sample firms whose employees' roles involved searching for knowledge access

reasons. My criterion for sampling was biotechnology firms that had experience of the Phase II human clinical trials process because my preliminary work suggested that this was where varying proximities were most likely to be influencing search practices. Of the seven firms identified, three agreed to participate in this study. Figure 8.3 summarises additional information about the participating firms (named with pseudonyms).

Data collection in the study was concerned with search practices that agents used to assist with knowledge access in relation to human clinical trials. At each firm, the agents involved in various aspects of preparation and execution of the clinical trials were interviewed using a semi-structured interview guide. The firms' small size saw all individuals involved in strategic and operational aspects of clinical trial work. Table 1 summarises additional information about the participants from each firm.

Themes in the interview guide included the nature of the interorganisational activities that individuals were involved in, their roles in clinical trials and the activities they used to search out knowledge. Interview data was complemented by firms' documents such as annual reports, by the researcher's field notes collected during local industry events where some of the workers had participated, and with publically available information, such as clinical trial documents available from regulatory agencies.

All data were collated and analysed from a practice perspective. Every activity related to searching that was reported by agents during the interviews and identified by the researcher in documents and observations was summarised. Agents' use of objects related to clinical trials was also identified and the ways that these were used was described. Examples of objects included regulatory documents, organisational charts, websites, email messages, databases and iPhones. The actual geographic distance between agents and the location of potential partners was identified and coded as a local source if within a day's drive, and as non-local if requiring more that one day for a return trip. Agents' perceptions about geographic proximity were gathered through interviews and observation data. These were coded as close or distant according to the agents' perceptions. Explanations qualifying perceptions of geographic proximity were also noted. Agents were also questioned as to whether they had considered geography in their search strategy. Responses to this question were coded as yes/no along with explanations about why these were or were not considered. Relational proximity was studied primarily through interviews. Agents were questioned

about their work history to ascertain the different cultural fields in which they had participated. They were also questioned about their preferred ways of working to provide some insight into their ways of knowing. When relational proximity was raised by agents as a factor in their search practices, additional questioning was used to clarify its influence.

**Figure 8.3: Summary of Case Firms in the Auckland Biotechnology Cluster**

| Firm: | TheraEye | TheraTume | TheraPan |
|---|---|---|---|
| Establishment: | Early 2000s | Early 2000s | Late 1980s |
| # of Staff | 13 | 19 | 33 |
| Location of agents | Auckland,<br>New Zealand (9)<br>San Diego, US (3)<br>London, UK (1) | Auckland,<br>New Zealand (3) (7)<br>San Diego, US (9) | Auckland,<br>New Zealand (28)<br>South Island,<br>New Zealand (5) |
| Location of collaborators | New Zealand<br>US<br>Australia<br>Canada<br>England<br>India | New Zealand<br>US<br>Taiwan<br>Canada | New Zealand<br>US<br>Australia<br>Italy<br>Russia |
| Roles of agents who participated in the study | Co-founder<br>CEO<br>CSO<br>COO<br>Clinical trial manager | Co-founder<br>Chairman<br>CSO<br>COO<br>Clinical trial manager | CEO<br>COO<br>Clinical trial manager |

Collection and coding methods provided a rich set of data on agents' search practices. To make sense of the data, inductive pattern searching (Gibbs, 2002) was used to ascertain patterns of search practices within the emerging cluster. To understand the influence of cluster life-stage, practices found in the emerging cluster were compared with those reported in existing cluster literature. To understand the influence of geographic and relational proximity, comparisons were made between the practices found within the emerging cluster.

## 8.5Findings

This study sought to understand how geographic proximity, cluster life stage and relational proximity influence the search practices that agents use to access knowledge. Evidence of these influences on the search practices of agents from three biotechnology firms in an emerging cluster is presented next.

### 8.5.1 Geographic proximity influences on search practices

With respect to geographic proximity, both similarities and differences were found in the search practices used to advance the various firms' products through human clinical trials (see Figure 8.4 for further illustrative examples). Agents used referrals when looking for knowledge that was in both close and distant geographic proximity to them. Agents relied often upon existing personal ties for local referrals. For non-local referrals agents used a mix of existing personal ties and newly created connections. For example:

> "The consultants were found basically by our CEO doing a lot of research. So sort of, you know going and meeting people, interviewing people... for instance our tox [toxicology] consultant; he was found from a lot of the recommendations that came from San Diego venture capitalist. They've got this huge portfolio of people they've used before. And they gave names to [our CEO]. And they gave him the name of a woman who was an oligo-type specialist. He went to her, and got some names off her. And we ended up with this tox consultant who does nothing but design tox programmes for oligos" (COO, TheraEye).

Non-local searching also involved internet browsing and reading peer-reviewed publications to identify experts in different fields. For example:

> "We also read papers... when we were designing some of our skin trials, we'd get a research paper and it's "oh who's the author on this? Let's actually contact him. And one of the guys, Tom S, had done a punch biopsy study just like our Phase I [clinical trial]. And we ended up talking to him on the phone, and meeting with him. And now

we've brought him on board as a consultant, because he's been so helpful" (COO, TheraEye).

**Figure 8.4: Examples of geographic proximity influences on search practices.**

| Close geographic proximity: collecting referrals |
|---|
| On looking for a statistician "one was on a recommendation from our chief medical officer" (Clinical Trial Manager, TheraEye).<br><br>"We would like to do a trial for diabetes here [in NZ], because we know that JB, who's head of diabetes at [a local public hospital] has done lots of clinical trials in diabetes...we are colleagues...he's known... it's a very small country, we know each other mostly" (COO, TheraPan). |
| Distant geographic proximity: collecting referrals. |
| "We've talked to other people and sort of said, "what do you know about this guy?" (COO, TheraEye).<br><br>"You look at the scientific leaders and you know who leaders in the field are. Our founder knows them from his entire professional career" (COO, TheraPan).<br><br>"We [the CSO and COO] speak to our colleagues in the field. We know who they are. We have standard criteria; they have to have an expertise in the field. Preferably they should have experience in early clinical trials, not just clinical trials. And they have to have an investigative approach to their work ... we talk to the Data Centre in Denver about doing trials for all these reasons. It's a major centre, we know it personally" (COO, TheraPan). |
| Distant geographic proximity: internet browsing. |
| In reference to looking for data management support services in a clinical trial, "a couple of them I just searched on the internet looking for people who had experience in our field" (Clinical Trial Manager, TheraEye).<br><br>In reference to identifying Clinical Research Organisations in Asia, "[I used] the internet and then phoning them up to ask them what they do. Before we started the Phase II trials we had to do a business plan around Phase II and a couple of them were really helpful in providing us with the data even before we had signed them up (COO, TheraTum). |

## 8.5.2 Cluster life stage influences on search practices

A small local labour market is the first characteristic of an emerging cluster (Menzel & Fornahl, 2010) that showed evidence of influencing agents' search practices. Studies of existing clusters report that localised labour pools can thrive because specialists find regular employment among a number of firms. In turn, firms are able to easily hire the expertise they require for short periods of time (Bresnahan, et al., 2001; Porter, 1998). In contrast, for the

emerging cluster the local labour market was small with few biotechnology firms and limited public science employment opportunities available. All of the firms had nonetheless used local universities, consultancy firms and patent attorneys. However, the small number of firms ran too few projects to offer regular employment, which limited the opportunity for development of a local labour pool with the skills the firms needed.

Lack of local labour became a greater problem when senior management expertise was sought, especially during Phase II. Established clusters provide a pool of senior management experience through job mobility (Casper, 2007) and serial entrepreneurship, (Myint, et al., 2005) where individuals are able to gain experience at all phases of the R&D process under the guidance and mentorship of experienced managers. In contrast, the Auckland cluster had very few experienced senior managers and even fewer experts at Phase II. The difficulty this presented is illustrated by one of the few agents with experience of taking a drug development project through the development phases:

> "There's a pretty strong FDA requirement; it's a pretty high regulative process. So, although I don't think that there have been too many examples of people being closed down, you can get put on hold — a clinical hold by the FDA — and that can be a death warrant because you keep running out of money as you try and get back into the clinic. They're all management things, and we're very light on the ground in New Zealand of people who have done that. There is a small group of people who have done bits of it. But there's not too many who have done the whole thing" (Chairman, TheraTum).

The second characteristic of an emerging cluster that influenced agents' search practices was technological heterogeneity (Menzel & Fornahl, 2010). In established clusters, spin-offs from existing firms and entrepreneurs with local experience ensure some homogeneity in the technologies developed (Myint, et al., 2005). New firm formation within an established cluster also maintains a knowledge infrastructure of commercial expertise (Baptista, 1998). However, for emerging clusters "their heterogeneity hampers exchange and limits possibilities for local networks, and customer–supplier relations are scarce" (Menzel & Fornahl, 2010 p. 225). Biotechnology firms in the Auckland cluster were developing products based on a diverse range of scientific knowledge, which limited the possibilities for the direct sharing of practices. The agents in this study were conscious of this issue, and of wider industry efforts to develop a local biotechnology cluster. Furthermore, each firm had made symbolic and

financial commitments to support cluster development. Nonetheless, where crucial development processes such as human clinical trials were concerned, the growth of the cluster was secondary to the growth of the firm. As the CEO of TheraEye said

> "If I told my investors that the company was crushed because of a mistake but the local industry learned a lot, they wouldn't be too happy".

As well as direct experience, agents' perceptions about the cluster also influenced their search practices. There was a collective belief at some firms that the cluster lacked specialised expertise at the development phase. Some agents reported there were few local experts their firm could employ and few firms to outsource specialist work. However, when pressed for evidence to back up their claims, agents referred back to the shared beliefs within the firm rather than any direct experience. Other agents who had direct experience of local searching reported that they had eventually declined local options because these were perceived as requiring significant coordination by the firm. Given that the firm was accessing knowledge from other cultural fields, agents did not want to enter into partnerships where they could not be confident that the partner's practices were appropriate in that field. In both of these situations agents' search practices (or decisions not to search) were influenced by perceptions of the cluster's life-stage.

### 8.5.3 Relational proximity influences on search practices

Similarities and differences in patterns of practices were also found about relational proximity. Using Unruh's (1979) social types, agents who shared close relational proximity with potential partners can best be described as Regulars whereas agents who shared distant relational proximity with potential partners can be described as Strangers. Regulars and strangers relied on different search practices (see Figure 8.5). Regulars reported using different combinations of the following: reading publications, cold calling and collecting referrals from weak personal ties. This is illustrated by the search practices of TheraEye's CEO that were described in an earlier example from TheraEye's COO. During his 20-year career TheraEye's CEO had been involved with multiple start-up senior management teams in North America and New Zealand. Through his experience he developed a wide array of practices from participation in different cultural fields that he could draw from in new situations.

**Figure 8.5: Relational proximity influences on search practices**

| Regulars (Unruh, 1979)<br>(Close relational proximity) | Strangers (Unruh, 1979)<br>(Distant relational proximity) |
|---|---|
| Reviewing publications<br>Cold calling<br>Referrals through weak ties | Internet browsing<br>Referrals through dense ties |

In contrast Strangers reported a heavy reliance on internet browsing and peers' referrals from dense ties. This was illustrated by TheraEye's clinical trial manager whose prior experience of pre-clinical and Phase I trial management at three universities, two pharmaceutical companies and another biotechnology start-up provided him with a useful array of practices when searching related to TheraEye's own Phase I projects. However, as the firm's projects moved into Phase II, the clinical trial manager became a Stranger because his strong ties from the preclinical cultural field were of limited use.

> "The main problem with drug supply is that the drug [used in clinical trials] needs to be kept frozen for long-term storage and chilled immediately prior to storage. The drug comes from the US, so you've got to get it through US Customs, and through New Zealand Customs. And then find somewhere where it can be stored at GMP, good manufacturing quality. [Researcher: were there a lot of options?] It's problematic actually. There are a few, but you've got to find someone that you can work with. [Researcher: did you know any?] No. I don't know how I found them actually, probably searched through the internet or something. I might have gone to the Medsafe web site actually. Maybe there were some GMP pharmacies, yeah. Oh, the other way we found out about them is I rang up the hospital pharmacy at Auckland Hospital and they said ring Optimus. I was going to get the hospital pharmacy at Auckland Hospital to do it. And they said "ring up Optimus, that's what they do" (Clinical Trial Manager, TheraEye).

In this situation the clinical trial manager had to build new weak ties in a new cultural field (in this example, logistics) because his strong ties from other cultural fields were of limited use.

## 8.6 Discussion

From this description of the search practices for knowledge access used by agents in the Auckland biotechnology cluster, it is clear that geographic proximity and relational proximity influenced search practices in different ways. Comparing practices from the emerging cluster to the ones reported in the literature on existing clusters showed that cluster life-stage influenced search practices in two ways. First, technological heterogeneity and a weak knowledge infrastructure within the emerging cluster meant that there were few local agents to learn from. Because of these conditions agents adapted their practices towards searching for geographically distant partners. This was less influential in studies of established clusters whose local search opportunities were greater. Second, the expertise required for Phase II trials resided in cultural fields that were unfamiliar to many agents in the cluster. Because of experienced-based differences, agents had to adapt their practices to search for relationally distant partners.

Characteristics of the Auckland biotechnology cluster indicate that early in the life of a cluster the expertise that firms need to access knowledge in order to develop complex products will come from relational proximity as well geographic proximity. While the purpose in this paper is to develop exploratory insights, it does support recent calls for greater consideration of cluster life-stage. In doing so it raises the interesting question of why agents did not put more effort into creating new local ties, rather than seeking expertise elsewhere.

Firms in an emerging cluster need a knowledge infrastructure to connect to and they must be confident about the quality of the expertise offered. Although the agents in my study had local access to universities' basic research expertise, firms often lacked local access to the Phase II expertise required for human clinical trials. In the context of an emerging cluster, one option might be for firms to develop that expertise. However, it is unrealistic for firms to develop every competency they need (Hamel, 1991) so they must decide what expertise they want to acquire and what they will access (R. Grant & Baden-Fuller, 2004). Given that biotechnology firms specialise in applied research (Powell & Brantley, 1992; Shan, et al., 1994), later phase expertise remains a knowledge access issue for them. In the context of an emerging

cluster, this means searching for geographically distant knowledge. This involves building non-local networks or pipelines that provide geographically distant search opportunities (M. S. Gertler & Levitte, 2005; Owen-Smith & Powell, 2004; van Geenhuizen, 2008). Efforts by the agents in my study to use non-local networks were consistent with these theoretical explanations.

Although agents adapted their search practices to varying geographic proximity, some situations required face-to-face interactions to assess relational proximity. In these instances agents did not adapt their practices to geography, but created temporary geographic proximity (Rychen & Zimmermann, 2008; Torre, 2008) by travelling to potential partners.

> "It's always better to have a meeting in person before we sign anyone up. Obviously we start with teleconferences, but once we had that face to face meeting, we got more traction with them" [COO, TheraEye].

Relational proximity also involves bodily aspects of practice that require close geographic proximity. As concluded by Moodysson and Jonsson (2007), tacit knowledge is more sensitive to geographic proximity than codified knowledge. The bodily aspects of interpreting facial expressions, observing seating posture and establishing chemistry between people demonstrate that searching are more than a cognitive activity. Agents' instincts towards potential partners employ unreflective reactions over an extended period. Interpreting these non-verbal communication codes uses bodily practices that are difficult, if not impossible, through electronic media, such as teleconferencing. For example:

> "I take all the proposals and choose the 2 or 3 best ones. Then I go and visit with them and just make sure I get that chemistry realising what they're like. I just talk to them as people rather than anything else around costs and that sort of thing" (COO, TheraEye).

Unruh's (1979) social types further explains the influence of relational proximity on search practices. Some agents relied upon referrals from their dense personal ties to identify expertise. Dense personal ties were useful when agents were operating as Regulars in cultural fields known to them because the status as Regulars affords them relational proximity. However relational proximity in one field had limited value when practices from other fields were required. In these situations some agents became Strangers and struggled to learn enough about the norms and ways of knowing in the new field to search effectively.

Furthermore, their personal ties were often unable to help them learn because these were embedded in the other fields of expertise.

In contrast, the challenges faced by Strangers in existing clusters are likely to be easier to overcome. In Silicon Valley, labour mobility is important for knowledge diffusion (Saxenian, 1994). Casper (2007) argues that labour mobility is an important factor in Silicon Valley because it enables workers to maintain regular employment in a high-risk industry, which in turn creates a strong local labour market. From the practice perspective, labour mobility is also likely to facilitate the diffusion of search practices in two ways. First, because there is a strong local labour market, through HR-recruitment biotechnology firms in Silicon Valley can reduce their need to use staff in contexts where they are likely to be Strangers. Secondly, for workers who find themselves as Strangers, the strong local labour market means there are more agents to obtain guidance and mentoring from, thus, enabling a faster transition from Stranger to Regular.

The agents described as Regulars relied on different practices to search out non-local knowledge sources. Regulars had personal networks with many weak ties that they used to help gain entry into other cultural fields. At the same time they read scientific publications to identify leading researchers and research organisations they could approach. In addition they would cold-call – either by telephone or in person – recognised researchers in the field whom they had identified as potential knowledge sources. They then used publication searching and their weak ties to verify initial impressions from cold calling. Even though these agents were not experts or insiders in the cultural fields from which they were searching, they had effective practices because they understood the norms and ways of knowing in the field. Furthermore, the repertoire of practices that they had built up by participating as Regulars aided agents' ongoing searching because those experiences gave them the ability and confidence to make more nuanced assessments of the firm's requirements.

## 8.7 Conclusion.

Knowledge access is a crucial innovation issue, especially for firms whose competitive advantages reside in them exploiting their knowledge base (R. Grant & Baden-Fuller, 2004;

Powell, et al., 2005). Search is the first step in the knowledge access process and is necessary when the firm's knowledge domain is insufficient to perform particular activities successfully (De Clercq & Dimov, 2008; Katila & Ahuja, 2002). However, search practices are strongly situation dependent making their transferability across contexts problematic (Broekel & Binder, 2007; Lave & Wenger, 1991; Suchman, 1987).

Extant studies of established knowledge-based clusters show that technology firms search locally because there are existing knowledge infrastructures to exploit. However, the influence of cluster life-stage is rarely considered in cluster research (Menzel & Fornahl, 2010). Recent studies suggest that relational proximity is also important for interorganisational learning (Amin & Roberts, 2008; Knoben & Oerlemans, 2006). While geographic proximity, cluster life-stage and relational proximity are known to influence learning, it was not clear how they influenced the search phase of the knowledge access process.

This study set out to explore how search practices are influenced by geographic proximity, cluster life-stage and relational proximity. In comparing the practices used in the emerging cluster to those reported in extant literature on established knowledge-based clusters, the study provides insights into how geographic proximity and cluster life-stage influence the practices that agents use to search out local and non-local knowledge. In comparing the practices from the emerging cluster that were used under varying relational proximity, differences in practices were explained using the Regulars and Strangers types in Unruh's (1979) participation typology.

This paper makes two important contributions to our understanding of interorganisational learning and innovation. First, geographic proximity and industrial clusters are often claimed to provide localised conditions for interorganisational learning (Krugman, 1991; Porter, 1998). Menzel and Fornahl (2010) argue that cluster life cycle models are needed to explain the evolution of clusters and they propose a life-stage model that distinguishes emerging and existing clusters. Findings from this study provided some initial empirical evidence in support of Menzel and Fornahl's (2010) model which suggests that future research on geographic proximity and interorganisational learning should consider the influence of cluster life-stage.

Second, relational proximity is proposed as another dimension of proximity that influences learning (Amin & Roberts, 2008; Knoben & Oerlemans, 2006). This study identified agents' search practices as one mechanism through which relational proximity influences

interorganisational learning. Agents who participate in different cultural fields have a wider array of practices — affording them close relational proximity — to use when searching, compared with agents who participate in fewer fields. Future research is needed to understand how relational proximity influences other interorganisational learning mechanisms.

The study also has public policy and managerial implications. Technology firms in emerging clusters develop practices to search out local and non-local knowledge. While cluster-building public policies seek to foster value for the local region (Roelandt & den Hertog, 1999), cluster-building efforts might benefit from policy-makers' consideration of how technology firms' non-local networking be supported for the benefit of the cluster. Similarly, closer attention to the types of agents involved in searching might assist cluster managers in directing their boundary spanning efforts. Given that one of their responsibilities is to act as co-ordinators (Fromhold-Eisebith & Eisebith, 2005), cluster managers might perform a more effective role by concentrating their efforts on those agents who as Strangers most need assistance in entering different cultural fields.

An important limitation of this study must be acknowledged before concluding. The case-based method was chosen because of the exploratory nature of the study and the focus on elaborating connections between existing theories about interorganisational learning and innovation. The intent of using a case study was to develop theoretical generalisations from patterns observed in the data and literature. The selection of a biotechnology cluster in Auckland New Zealand was done because it represented a typical case (Patton, 1980; Yin, 1994) that illustrated the characteristics of an emerging cluster under investigation. The firms within the cluster were selected because their human clinical trials activities illustrated the challenge that firms face in searching for innovation partners. While the situated nature of practices means that some of the search practices reported in the case might be idiosyncratic to the Auckland biotechnology cluster, others will be recognisable as search practices. The very nature of the practice perspective is that the knowledge embedded in practices is socially situated. It is intended that by providing sufficient information about the firm and the cluster context in which the search practices are situated, the reader can appreciate how the notions of experience-based differences can be transferred (Lincoln & Guba, 1985) in order to understand how firms learn to search for innovation partners in other contexts.

**Appendix 1: Auckland Human Therapeutics cluster R&D pipeline, 2006.**

| Organisation | Drug Candidate | Discovery | Pre-clinical | Phase I | Phase II | Phase III | In Market |
|---|---|---|---|---|---|---|---|
| Auckland Cancer Research Society* | Amsacrine | | | | | | |
| | MLN 944 | | | | | | |
| | DMXAA | | | | | | |
| | SN30711 | | | | | | |
| | Nitrooxazines | | | | | | |
| | Perforin inhibitors | | | | | | |
| | P13 Kinase Inhibitors | | | | | | |
| | XR11576 | | | | | | |
| | Canternib | | | | | | |
| | Asulcrine | | | | | | |
| | DACA | | | | | | |
| CoDa Inc | Nexagon | | | | | | |
| | | | | | | | |
| | | | | | | | |
| CoDa NZ | Peptagon | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| Genesis Research & Development | Zyrogen | | | | | | |
| | | | | | | | |
| | RNAi | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | MED-1 | | | | | | |
| | PVAC | | | | | | |
| | | | | | | | |
| | AVAC | | | | | | |
| | | | | | | | |
| | SRP299 | | | | | | |
| IRL** | Fosidine | | | | | | |
| | BCX- 4208 | | | | | | |
| | MT-DADME | | | | | | |
| Living Cell Technologies | Diabe Cell | | | | | | |
| | Neurotrophic Cell | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | Fac8Cell | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Neuren | Glypromate | | | | | | |
| | NNZ-2566 | | | | | | |
| | | | | | | | |
| | Motiva | | | | | | |
| | Motiva | | | | | | |
| | Motiva | | | | | | |
| | Motiva | | | | | | |
| | NNZ-4945 (NRP) | | | | | | |
| | NNZ-8000 | | | | | | |
| | NNZ-2591 (DKP) | | | | | | |
| | Macrocyclics | | | | | | |
| | Anti-TFF mAbs | | | | | | |
| | Anti-hGH mAbs | | | | | | |
| | GH Variants | | | | | | |
| Proacta | PR104 | | | | | | |
| | SN29730 | | | | | | |
| | SN30000 | | | | | | |
| Protemix | Lazarin | | | | | | |
| | PX 811013 | | | | | | |
| | EN 122004 | | | | | | |
| | PX 811016 | | | | | | |
| | EN122001 | | | | | | |
| | En122022 | | | | | | |
| Virionyx | PEHR G214 | | | | | | |

[#] some drug candidates are tested on multiple medical conditions; *is a not-for-profit organisation; **is a Public Research Organisation; ▬ R&D stopped.

Table adapted from: Whitcher, G. and Callagher, L. (2007) *Building Intellectual Capital in new industries: The role of Social and Human Capital in Auckland's drug discovery and development cluster*. Working Paper to Special Interest Group - Human Therapeutics (SIG-HT) and New Zealand Trade and Enterprise (NZTE). University of Auckland Business School.

# 9 STUDY 4 - LOCATIONS OF INNOVATION AND THEIR INFLUENCE ON PARTNER SELECTION PRACTICES[3]

Abstract: The location of innovation remains an important management issue. Recognising that location can take multiple forms – geographic and relational, and multiple dimensions – proximate and distant, that operate in combination (not isolation), this paper explores how the location of innovation location influences partner selection practices for innovation. I propose a conceptual matrix to explore their influence on the partner selection practices used in biotechnology firms in an emerging industrial cluster and address whether and why differences in location influence partner selection for innovation. Results show that verifying complementarities and reviewing prior experience are prevalent partner selection practices irrespective of location combination. However, whether firms create geographic proximity or use temporary geographic proximity depends upon what relational location dimension is present.

Geographic and relational proximity are increasingly understood as important influences on knowledge processes associated with innovation (Amin & Cohendet, 2004; Fagerberg,

[3] Callagher, L. (2010) Locations of innovation and their influence on partner selection practices, *24th Australia and New Zealand Academy of Management Conference proceedings*, Adelaide 8-10 December

Mowery, & Nelson, 2005; Knoben & Oerlemans, 2006; Oerlemans & Meeus, 2005). Geographic proximity facilitates the efficient sharing of implicit and tacit aspects of knowledge through face-to-face communication, body language and in-situ demonstration (Howells, 2002) due to the "close spatial or physical distance between economic actors both in its absolute and relative sense" (Boschma, 2005 p. 69). Relational proximity enables actors to recognise and value knowledge due to the relative closeness among actors in regards to their norms, values, and rules of thought and action and ways of knowing (Amin & Roberts, 2008; Coenen, et al., 2004; Lechner & Dowling, 2003). What unites the different dimensions of proximity is that they contribute to reducing uncertainty and to facilitating learning and innovation (Boschma, 2005).

Still, for actors who operate in emergent industrial clusters where few firms, a small labour market and knowledge heterogeneity afford limited local learning opportunities (Menzel & Fornahl, 2010), geographic or relational proximity are not always present. Despite the opportunity-impoverished environment, firms still try to innovate with geographically or relationally distant actors. Hence, the practices in these firms can use to address one particularly relevant issue in the management of innovation, namely the ways that varying geographic and relational location can influence partner selection.

This paper addresses how firms operating in an emergent industrial cluster adapt their practices for partner selection to varying geographic and relational location while trying to innovate. My perspective in this paper draws upon two bodies of theories, one around the geographic location of innovation and the other around the relational location of innovation. Upon reviewing these theories I propose a conceptual matrix that allows me to explore the influence that different forms and dimensions of location have on partner selection practices. This enables me to address if, and why, differences in location influence partner selection practices. I chose theoretically relevant case studies of biotechnology firms within one emerging industrial cluster to illustrate the matrix because recent work on industrial clustering and innovation has highlighted the biotechnology industry as an extreme example of how innovation is linked to location (Powell, et al., 1996; Powell, et al., 2005; 1997, 2001; Swann, et al., 1998).

Knowledge processes associated with innovation are often characterised by uncertainty and complexity. One way that firms manage the uncertainty and complexity is to collaborate

with other actors. Collaboration can take many forms (formal versus informal, arms-length versus deeply embedded) and can be done for different reasons (knowledge acquisition versus knowledge access). However, all forms of collaboration involve a partner selection decision whereby the firm assesses which potential partner offers the best value and the judgement to enter into an arrangement is made (Geringer, 1991; Hitt, Dacin, Levitas, Arregle, & Borza, 2000). Complementary skills offered by the potential partner, the likelihood that a cooperative culture can exist between the firms, the compatibility of the firms' goals and the commensurate levels of risk viz-a-viz rewards and prior experience are recognised as common criteria for partner selection decisions (Brouthers, et al., 1995; Gulati, 1995; Hoang & Rothaermel, 2005). In this paper I concentrate on partner selection practices where the selection decisions are intended for knowledge access purposes, that is applying knowledge from a partner's knowledge domain to the firm's own products with the intention of maintaining the distinctive knowledge bases of both firms (R. Grant & Baden-Fuller, 2004). Unfortunately, collaboration for knowledge acquisition purposes in beyond the scope of this paper.

## 9.1 Dissecting the concept of the location of innovation

Since Marshall (1920) the location of economic activities has been a constant issue in a number of disciplinary fields. More recently scholarly and public policy interest in the location of innovation has been re-kindled in a number of quarters. These include the institutional and evolutionary approaches in organisational economics (Stefano Breschi & Lissoni, 2001; Cowan, et al., 2005; C. Freeman & Soete, 1997; Malerba, 2006), the embeddedness of firms in systems of innovation perspectives (Edquist, 1997; B. Lundvall & Johnson, 1994; Malerba, 2002), the benefits of industrial agglomeration, such as the success of the Silicon Valley and other high-technology clusters (Porter, 1998; Saxenian, 1994; Swann, et al., 1998) and the Knowledge-Based View (R.M. Grant, 1996a; Peter Maskell, 2001).

Underpinning the relationship between location and innovation are a number of characteristics about the nature of knowledge and knowledge processes. Knowledge is a core feature of innovation because the production of new goods or services usually involves the

creation and integration of different types of knowledge (Howells, 2002; Kogut & Zander, 1992; Nonaka, 1994). But knowledge is 'sticky' making it difficult to pass on to people in other locations (von Hippel, 1994). The stickiness is due to relational aspects that situate the production and reproduction of knowledge in everyday practices (Lave & Wenger, 1991) which are imbued with meaning according to the beliefs, values and norms shared by practitioners within that particular field of practice (Bourdieu, 2005).

Because of these knowledge characteristics both geographic and relational proximity are important to innovation. However, what is less clear is when geographic and relational proximity are critical for innovation, how they interact with one another and the effect that this has on innovation (Boschma, 2005). The aim of this section is to review what is known about the role of geographic and relational proximity for innovation and to set out a conceptual matrix that allows me to explore how their presence, absence and combination influences partner selection practices for knowledge access.

### 9.1.1The geographic location of innovation

The relationship between geography and innovation is often explained in terms of knowledge spillovers. Empirical studies show that when knowledge spills over from one actor it is more likely to be appropriated and used by another actor when the two parties are in geographic proximity (D. Audretsch & Stephan, 1996; Jaffe, et al., 1993; Zucker & Darby, 1998). Audretsch and Feldman (1996b) extend explanations of the geographic clustering of innovation activities proposing that geographic clustering is linked to industry life-cycle stage. Analysing the citation and location data of 2400 commercial innovations, they found the propensity to cluster is greatest in industries with a dependence on new economic knowledge and that strong clustering effects are associated with the early stages of the industry life-cycle. Audretsch and Feldman (1996b) concluded that geographic proximity matters most during the early stages of the industry life cycle because this is when tacit knowledge is most important for innovative activity. Prevezer (1997) found similar patterns in her study of the formation of US biotechnology clusters concluding that the presence of a strong science base at those locations, which is a critical input for innovation in the industry, explained clustering patterns.

According to these arguments, we should expect that geographic proximity to influence partner selection in a number of ways. Given that spatial closeness is known to support knowledge spillovers, it is likely that knowledge about potential partners also spills over. In addition, spatial closeness also facilitates learning, so it is likely that learning about potential partners to inform partner selection decisions is also likely [see Figure 9.1, cell a].

**Figure 9.1. Geographic and Relational Location as Influences on Partner Selection Practice.**

| Location Forms & Dimensions | | Geographic Location | |
|---|---|---|---|
| | | a. Proximate | b. Distant |
| Relational Location | c. Proximate | | |
| | d. Distant | | |

## 9.1.2 Emerging cluster life-stage and innovation

The relationship between geography, innovation and life cycle is also suggested by Baptista (1998), Bergman (2007), Pouder and St. John (1996) and Menzel and Fornahl (2010). They concur that the geography of innovation is linked to life-cycle because of the characteristics of knowledge. However, these authors argue that cluster life-cycle differs from industry life-cycle and is equally important to understanding the geographic location of innovation. This is because the knowledge resources that clustering provides differ across life-cycle stages, thus influencing the opportunities for learning and innovation.

Using Porter's (1998 p. 78) definition of clusters as "geographic concentrations of interconnected companies and institutions in a particular field", Menzel and Fornhl (2010) propose that clusters go through life-cycle stages of emergence, growth, sustainment and decline. Each stage can be characterised by differences in the number of firms, employees and the nature of the localised knowledge base.

For clusters that are in the growth or sustainment stages, the geographic location of innovation can be in close proximity because the number of firms and employees is sufficient

to generate localised learning opportunities. However, for clusters in the emerging stage this effect is likely to be opposite. Because there are few firms and a small local labour market to draw from, it is likely that at least some learning opportunities for innovation will be at geographic distance [see Figure 9.1, cell b]. Thus, given my interest in this paper on the influence of varying geographic location on partner selection, firms operating in emerging industrial clusters are likely to provide evidence of this phenomenon.

### 9.1.3 The relational location of innovation

A more recent perspective on the relationship between geography and innovation is the relational approach. Relational proximity refers closeness of relations in terms of norms, values and rules of thought and action (Coenen, et al., 2004). These aspects of relational location highlight the situated nature of practices, which are concerned with the different ways of knowing and not only the geographic location where knowing takes place (Amin & Roberts, 2008). Relational proximity is referred to by some authors as social proximity. However Boschma (2005) convincingly points out to social proximity as a separate form of proximity. Thus, for conceptual clarification I explicitly concentrate on relational proximity only.

Relational proximity is important because it assists actors in recognising and valuing practices that are performed in different fields of practice (Amin & Roberts, 2008). While actors cannot share exactly the same meanings, similar mental models provide common understandings about 'how and why' things are done (Turner, 1994). During partner selection, similarities act as a selection heuristic that reduces the uncertainty and risk associated with collaborating in the open market (Podolny, 1994). Hence relational proximity is likely to make it easier for actors to recognise practices and judge whether those practices are performed in ways that will benefit the firm [see Figure 9.1, cell c].

In biotechnology expertise is required from a number of fields of practice; for instance, molecular biology, biochemistry, toxicology, manufacturing control and monitoring; (Pisano, 2006a). Given that no firm can master all the domains of expertise required (Powell & Brantley, 1992), selecting partners to collaborate with is a characteristic of the industry. For firms in an emerging industrial cluster this is likely to be a greater necessity because the

technological heterogeneity between firms restricts relational proximity. Therefore is it likely that at least some partner selection practice occur under the influence of relational distance [see Figure 9.1, cell d].

Existing literatures reviewed suggests that each form of location (geographic and relational) and each dimension (proximate and distance) is likely to influence partner selection papers in different ways. However, the different forms of location do not exist is isolation to other another but exist simultaneously (Knoben & Oerlemans, 2006). In order to understand their influence on partner selection practices it is necessary to explore the combinations location forms and dimensions on innovation (See Figure 9.2).

**Figure 9.2. Combinations of Location Influences on Partner Selection Practice.**

| Location Forms & Dimensions | Geographic Location | |
|---|---|---|
| Relational Location | Geographic Proximity / Relational Proximity | Geographic Distance / Relational Proximity |
| | | |

## 9.2 Research design and method

My research design combines theoretical reasoning with explorative case studies of three biotechnology firms operating in an emerging industrial cluster whose partner selection practices illustrate the four theoretically derived quadrants identified so far. My embedded case study methodology draws upon a typical case sampling approach (Patton, 1980; Yin, 1994) to identify a biotechnology cluster specialising in human therapeutics in Auckland, New Zealand as a context that demonstrates the characteristics of an emerging cluster as specified by Menzel and Fornahl (2010) and where activities were influenced by varying geographic and relational location. Then selecting for theoretically relevant cases (Eisenhardt, 1989), I identified three biotechnology firms whose partner selection practices strengthen and explain the theoretically derived propositions. The combination of the theoretical review as well as the

empirical cases should help to develop a more coherent and detailed set of hypothesis in further research as a result of the analysis.

### 9.2.1 Case Sampling Methods

An emerging human therapeutics cluster in Auckland, New Zealand, presented a typical case of an emerging cluster offering firms a limited number of knowledge infrastructure inputs. Three of the country's eight state-funded universities are based, or have large campuses, in Auckland. In addition, a number of professional service firms provide industry-specific accountancy, management consultancy and legal services. In regards to the technology, human therapeutics is a sub-category of the biotechnology field that is concerned with the discovery and application of remedies for disease. In the early phases of drug development, biotechnology firms in the study could rely upon the scientific expertise available from these local organisations, especially public science organisations. Thus, some partner selection opportunities for significant areas of their operations were in close geographic and relational proximity to the biotechnology firms.

On the other hand, as products moved into pre-clinical trials — which involve testing on animals — and Phase I and Phase II human clinical trials — involving testing on small numbers of human subjects — knowledge must be sought from a wider range of knowledge domains. Regulatory knowledge is required, as is, toxicology, chemistry, manufacturing control and monitoring expertise (Pisano, 2006a). At the time of data collection, few firms in the Auckland cluster had direct experience of drug development beyond Phase I human clinical trials and there was limited regulatory, clinical research, manufacturing and marketing services available locally (Ernst&Young, 2003). In addition, the cluster is physically isolated from other hubs of biotechnology activity. Australia, which has a number of clusters, is a three-hour international fight away, Asian destinations require at least ten-hour flights and Auckland-Los Angeles is a 12-hour one-way trip. Thus, some partner selection opportunities for significant areas of their operations were geographically and relationally distant to the biotechnology firms.

Having identified a cluster that exhibited the characteristics under investigation, my next step was to theoretically sample firms whose employees' roles involved partner selection for

knowledge access reasons. My criterion for sampling was biotechnology firms which had experience of preparing for the Phase II human clinical trials process because my preliminary work suggested that this was where varying proximities was most likely to be influencing partner selection practices (Whitcher & Callagher, 2007). Figure 9.3 summarises additional information about the three who agreed to participate in this study.

**Figure 9.3: Summary of Case Firms in the Auckland Human Therapeutics Cluster.**

| Firm: | TheraEye | TheraTume | TheraPan |
|---|---|---|---|
| Establishment: | 2003 | 2001 | 1987 |
| # of Staff | 13 | 19 | 33 |
| Nature of Product | Wound care and tissue repair | Cancer therapeutics | Diabetes, neurological disease and haemophilia |
| # of Products and Trial Phase | 2 products; one in Phase I & one in Phase II | 1 product; in Phase II | 3 products; one in Phase I & one in Phase II |
| Location of actors | Auckland,<br>New Zealand (9)<br>San Diego, US (3)<br>London, UK (1) | Auckland,<br>New Zealand<br>(3) (7)<br>San Diego, US<br>(9) | Auckland,<br>New Zealand (28)<br>South Island,<br>New Zealand (5) |
| Location of collaborators | New Zealand<br>US<br>Australia<br>Canada<br>England<br>India | New Zealand<br>US<br>Taiwan<br>Canada | New Zealand<br>US<br>Australia<br>Italy<br>Russia |
| Roles of actors who participated in the study | Co-founder<br>CEO<br>CSO<br>COO<br>Clinical trial manager | Co-founder<br>Chairman<br>CSO<br>COO<br>Clinical trial manager | CEO<br>COO<br>Clinical trial manager |

## 9.2.2 Data collection and analysis.

Data collection for the study was concerned with partner selection practices that actors used to assist with knowledge access in relation to human clinical trials. At each firm the actors involved in various aspects of preparation and execution of the clinical trials were interviewed using a semi-structured interview guide. The firms' small size saw all participants involved in strategic and operational aspects of clinical trial work. Figure 9.3

summarises additional information about the participants from each firm. Themes in the interview guide included the nature of the interorganisational activities that individuals were involved in, their roles in clinical trials and the activities they used to select partners. Interview data was complemented by firms' documents such as annual reports, by the researcher's field notes collected during local industry events where some of the workers had participated, and with publically available information, such as clinical trial documents available from regulatory agencies.

All data was collated and analysed from a practice perspective. nVivo qualitative software was used to aid the coding process. Every partner selection activity that was reported by actors during the interviews and identified by the researcher in documents and observations was categorised. The initial coding was then reviewed to ensure that each category represented a distinct partner selection activity. In total, 10 partner selection activities were identified in the data (see Figure 9.4 for the activities and the number of times their use was reported).

Next, the geographic and relational location of partner selection activities was coded using four distinct categories that represented the different forms and dimensions of location: geographic proximity, geographic distance, relational proximity and relational distance. The actual geographic space between actors and each potential partner was identified and coded as a local source if within a day's travel, and as non-local if requiring more that one day. Actors' perceptions about geographic location were gathered through interviews and observation data. These were coded as proximate or distant according to the actor's perceptions. Explanations qualifying perceptions of geographic location were also noted. Actors were also questioned as to whether they had considered geography in their partner selection decision-making. Responses to this question were coded as yes/no along with explanations about why geography was or was not considered.

**Figure 9.4: Partner Selection Activities reported for each type of innovation location**

| Geographic Proximity | | Geographic Distance | | Relational Proximity | | Relational Distance | |
|---|---|---|---|---|---|---|---|
| Complementarities | 10 | Complementarities | 11 | Complementarities | 9 | Complementarities | 8 |
| Prior experience | 6 | Prior experience | 7 | Prior experience | 7 | Prior experience | 4 |
| Trustworthiness | 5 | Trustworthiness | 6 | Trustworthiness | 6 | Trustworthiness | 3 |
| Convenience | 4 | Create geographic proximity | 6 | Temporary geographic proximity | 6 | Create geographic proximity | 3 |
| Financial cost | 2 | Temporary geographic proximity | 5 | Financial cost | 4 | Convenience | 1 |
| Attraction | 2 | Reputation | 4 | Convenience | 3 | Financial cost | 1 |
| Recommendation | 1 | Financial cost | 3 | Reputation | 3 | Attraction | 1 |
| Create geographic proximity | 1 | Attraction | 2 | Create geographic proximity | 2 | Reputation | 1 |
| Temporary geographic proximity | 1 | Recommendation | 2 | Attraction | 2 | Temporary geographic proximity | 1 |
| Reputation | 0 | Convenience | 1 | Recommendation | 1 | Recommendation | 0 |

Relational location was studied primarily through interviews. Actors were questioned about their work history to ascertain the different fields of practice that they had participated. They were also questioned about their work methods to provide some insight into their ways of knowing. When relational proximity or distance was raised by actors as a factor in their partner selection decisions, additional questioning was used to clarify its influence.

Collection and coding methods provided a rich set of data on actors' partner selection practices. To make sense of the data, inductive pattern searching (Gibbs, 2002) was used to ascertain patterns of partner selection practices within the emerging cluster. This involved querying the data to identify patterns between the four categories of location form and dimension and the 10 partner selection activities. First, this was done independently for each category (e.g.: geographic proximity influence only on partner selection) and then it was done for the combinations proposed in the conceptual framework (e.g.: geographic proximity/relational proximity influence on partner selection). To understand the influence of geographic and relational location on partner selection, the results of the pattern recognition analysis are presented next.

## 9.3 Findings and discussion

The theoretically sampled case studies from an emerging industrial cluster were designed to explore ideas about geographic and relational location of innovation as influences on partner selection practices for knowledge access. Given the two fields of theories regarding of the location of innovation, the aim is to address whether and why differences in proximity influence partner selection practices. From this explorative study there is some evidence to support the thesis that proximity does influence partner selection practices. However, there is also evidence that suggests that some partner selection practices remain constant irrespective of geographic and relational location.

In this section I will present two sets of findings. First I will present and briefly discuss the influences of the different forms and dimensions of location (i.e.: the four categories) on partner selection practices. This is necessary to appreciate the influence of their combinations on partner selection. Then I will present the combinations of the categories as proposed in the conceptual framework have on partner selection. Given the aim of the paper to explain when and why location influences partner selection, it is worthwhile focussing on the partner selection practices that do change under varying location.

### 9.3.1 Influence of Independent Forms of Proximity on Partner Selection Practices

When reviewing Figure 9.4 it is clear that verifying complementarities between the firm and the potential partner, reviewing prior experience and determining trustworthiness are prevalent partner selection activities irrespective of the form (geographic or relational) and dimension (proximate or distant) of location. Furthermore, these types of activities can be explained by extant literature. First, the very reason for accessing knowledge is to exploit those aspects of the partner's expertise which the firm lacks (R. Grant & Baden-Fuller, 2004). To do this the firm must assess what potential partners offer and verify whether that knowledge complements the firm's own products. Reviewing prior experience is part of partner selection because it provides an indicator for subsequent relations. Gulati (1995)

demonstrated that repeated alliances reduce uncertainty, risk and opportunism, thus in considering partners for future collaborations, firms review their prior experience with partners who can offer complementary knowledge. Determining trustworthiness is also necessary because the firm must establish that a potential partner's competence is sufficient (Nooteboom, et al., 1997). Given that information asymmetry makes this difficult for innovation collaborations (Blomqvist, et al., 2005), prior experience an important proxy for this judgement.

In contrast, there are a number of partner selection practices that appear more prevalent under certain locational conditions. When geographic distance is present, creating geographic proximity and creating temporary geographic proximity become more common practices. Prima facia, this suggests that there is an argument for the geography of innovation. However, the prevalence of these activities changed when other forms and dimensions of location are considered.

When geographic proximity is present, convenience becomes prevalent in partner selection decision-making. In theorising the value of industrial clustering, both Krugman (1991) and Porter (1998) espouse the value created through the speed of using local firms. However, the convenience of localised knowledge resources only mattered when the knowledge-based criterion of complementarities was fulfilled suggesting there is a range of criteria.

When relational distance is present, creating geographic proximity becomes a prevalent activity for partner selection. This can be expected because in order to choose a partner who participates in a different field of practice, it is necessary to learn something of the ways of knowing and communicating in that field (Moodysson & Jonsson, 2007). In contrast, the creation of temporary geographic proximity was not prevalent when relational distance is present. This is because when you have different fields of practice, temporary geographic proximity is unlikely to be adequate to develop sufficient understandings of those practices in order to make partner selection decisions. Thus, by establishing offices close to potential partners' geographic proximity is created which aids in gaining access to tacit knowledge of the different fields of practice.

In contrast, when relational proximity is present, temporary geographic proximity (Torre, 2008) was sufficient and the creation of geographic proximity was less common. This suggests

that when firms share similar ways of knowing with the potential partner, the use of short- or medium-term visits are sufficient for the partner selection decision.

### 9.3.2 Combined Geographic and Relational Location influences on Partner Selection Practices

I have argued that geographic and relational location of innovation does not operate in isolation; firms experience both forms of locational influence concurrently. According to the conceptual model four types of locational influences can occur: Geographic Proximity / Relational Proximity; Geographic Proximity / Relational Distance; Geographic Distance / Relational Proximity, and Geographic Distance / Relational Distance. Figure 9.5 shows that verifying complementarities between the firm and the potential partner and reviewing prior experience remain prevalent irrespective of the location form and dimension. However the prevalence of other partner selection activities changed.

When geographic and relational proximity are present, financial cost and convenience were slightly less likely to be reported as partner selection practices. Literature on innovation and collaboration often claims that the advantages of co-location relate to knowledge sharing efficiencies and spontaneous interaction (Feldman, 1994; Porter, 1998; Powell, et al., 1996). Data for these cases suggests that such claims should be curbed with a caveat that cost and convenience are less important that complementary knowledge and prior experiences. This pattern has consequences for firms wanting to collaborate in industrial clusters and for public policy that seeks to facilitate local innovation systems, both of which I will elaborate on in the final section.

The importance of complementarities and prior experience becomes even more important when geographic proximity and relational distance are present. Under these conditions other partner selection activities were rarely reported and determining trustworthiness was used substantially less. Trust judgements that are competence-based are difficult when they are made in a different area of expertise (Levin & Cross, 2004). This was the situation that participants found themselves in and under those conditions; they relied upon their most prevalent practices. However, when firms had relational proximity but lacked geographic

proximity they continued to determine trustworthiness of potential partners, suggesting that relational location influences the ability of firms' to use the assessment of trustworthiness as a partner selection practice.

**Figure 9.5: Combined Geographic and Relational Location influences on Partner Selection Practices**

| Geographic Proximity/ Relational Proximity | | Geographic Proximity/ Relational Distance | | Geographic Distance/ Relational Proximity | | Geographic Distance/ Relational Distance | |
|---|---|---|---|---|---|---|---|
| Complementarities | 8 | Complementarities | 4 | Complementarities | 7 | Complementarities | 6 |
| Prior experience | 5 | Prior experience | 2 | Prior experience | 5 | Prior experience | 3 |
| Trust worthiness | 4 | Trustworthiness | 1 | Trustworthiness | 5 | Create geographic proximity | 3 |
| Convenience | 3 | Attraction | 1 | Temporary geographic proximity | 4 | Trustworthiness | 1 |
| Financial cost | 2 | Convenience | 1 | Reputation | 3 | Reputation | 1 |
| Attraction | 1 | Create geographic proximity | 0 | Attraction | 2 | Financial cost | 1 |
| Create geographic proximity | 1 | Reputation | 0 | Financial cost | 2 | Temporary geographic proximity | 1 |
| Temporary geographic proximity | 1 | Financial cost | 0 | Create geographic proximity | 2 | Attraction | 0 |
| Recommendation | 1 | Temporary geographic proximity | 0 | Recommendation | 1 | Recommendation | 0 |
| Reputation | 0 | Recommendation | 0 | Convenience | 1 | Convenience | 0 |

In addition to trustworthiness, sometimes firms would create temporary geographic proximity when they experienced geographic distance and relational proximity. This often included short trips to visit potential partners at the partner's geographic location or attendance at conferences. These types of activities reinforce Torre's (2008) argument that temporary geographic proximity is sufficient in many circumstances. However, when we look at the partner selection practices used under geographic and relational distance, the use of temporary geographic proximity is limited. Instead, activities that create geographic proximity, such as establishing an office in geographic close to potential partners, are more

common. What these patterns suggest is that relational proximity is necessary for individuals to be able to benefit from temporary geographic proximity.

## 9.4 Conclusion

In this paper I set out to explore how the geographic and relational location of innovation influences partner selection practices for innovation. Literatures about these different forms of location have established that both geographic and relational proximity are important for innovation. However, as I have argued geographic and relational location of innovation do not operate in isolation; firms experience both location forms and dimensions concurrently. By applying the conceptual matrix to firms in an emergent industrial cluster I have explored when and why the different combinations of location influence partner selection practices. My study concludes that when relational proximity and geographic distance are present, firms use geographic temporary proximity. This is sufficient because the existence of shared ways of knowing allows actors to work together using communication technologies. However, when relational and geographic distance is present, firms create geographic proximity because it is necessary to learn the ways of knowing in the other field of practice.

As well as contributing to the literature on the location of innovation, my study also has practical implications. For the firms in this study assessing complementary knowledge and prior experience take priority to assessing financial cost and convenience during partner selection. Based on these cases policy makers proposing innovation initiatives, such as clusters or communities-of-practice, should focus on understanding the complementarities that exist within the fields of practice and facilitate collaborations around them. This is likely to be more beneficial to firms' partner selection practices than promoting the cost and convenience aspects. This is especially the case in emergent industrial clusters where few firms, small labour market and technological heterogeneity are likely to experience relational distance among potential innovation partners.

# 10 CONCLUSION

This chapter summarises the purpose of the research and explains the contribution of the studies to the field. I start by re-stating the research questions and summarising the research that was undertaken. Next, I explain the contribution these studies make towards developing a more micro-level explanation of learning and knowledge practices for innovation. Finally, I consider the implications of the findings for future research.

## 10.1 Innovation in an emerging biotechnology cluster

In 2001 the New Zealand government began to facilitate development of a biotechnology industry in New Zealand by implementing various public policies to promote innovation (New Zealand Office of the Prime Minister, 2002). Focus on a biotechnology cluster in Auckland, New Zealand, reflected a need to expand existing science and commercialisation expertise in the Auckland region (BIOTENZ & NZTE, 2003; Kistler & Husted, 2005). The emerging nature of biotechnology in New Zealand motivated the research problem, *when innovation requires expertise from different knowledge domains, how do firms learn when there are few experts to learn from?*

Recognising that industrial cluster life-stage, interactive learning in the innovation system and knowledge-based development are likely to influence firms' learning and knowledge processes as they access expertise for innovation,

1. *What obstacles do biotechnology firms in emerging industrial clusters face to accessing expertise for innovation?*

Motivated by findings to the first research question, process of innovation models, and, the practice-based view of learning and knowing,

2. *How are individuals' search and selection practices for firms' innovation influenced by geographic and relational location?*

## 10.2 A multi-level exploration of learning and knowledge for innovation

To address these questions I undertook two survey-type literature reviews in order to develop the research model. Review of organisational learning and organisational knowledge literatures (chapter 2) identified the practice-based view as a useful perspective for exploring the cognitive and social aspects of learning and knowing. Review of innovation theories and management perspectives (chapter 3) identified evolutionary, dynamic and processual explanations of innovation. However, these did not sufficiently explain firms' and individuals' learning and knowledge processes for innovation in the emerging Auckland biotechnology cluster.

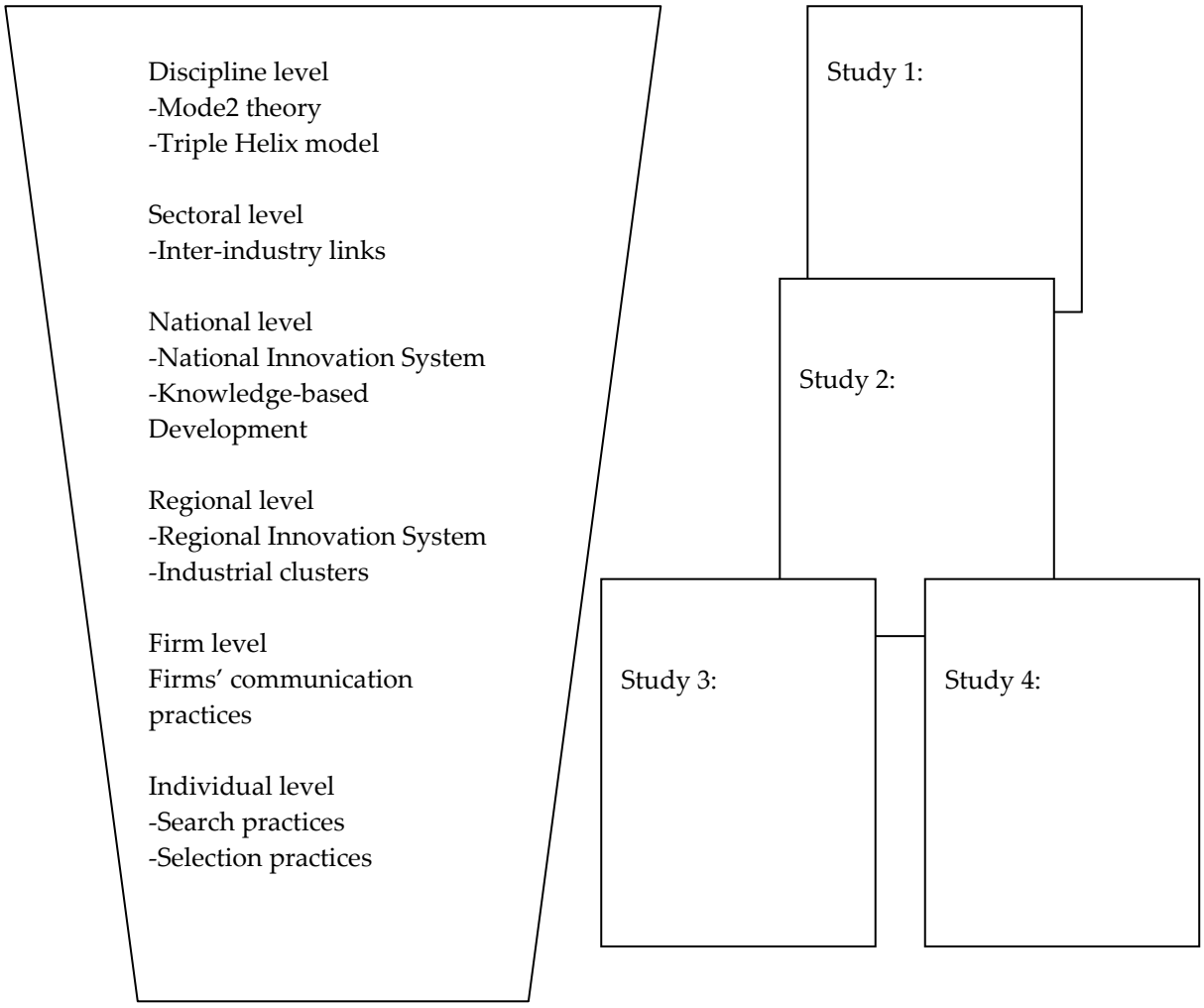
I developed a research model that utilised a range of theoretical perspectives from organisational learning, organisational knowledge, systems of innovation, and processes of innovation (chapter 4). For this particular research it was relevant to draw on theoretical perspectives that appreciate the role of firms' processes and individuals' practices for innovation, as well as the wider context in which these occur. Thus, the research model captures the multidisciplinary and multi-level nature of innovation and a number of influences on innovation in the emerging biotechnology cluster in Auckland, New Zealand.

To address the multi-level nature of innovation, I used an exploratory and evolving approach to the research methods (chapter 5). This included using seven different data sources and three different analysis techniques, which enabled investigation of learning and knowledge for innovation across different levels. After the methods were explained I operationalised the research model in four intellectually related research studies that were reported as independent research papers (chapters 6-9).

## 10.3 Contributing towards a multi-level understanding of learning and knowledge for innovation

Innovation in disciplines, sectors, nations, regions and clusters has received considerable examination by innovation scholars. Yet despite the efforts of scholars to examine innovation at these more macro levels, there remains a gap in explaining innovation at more micro-levels of the innovation system. Organisational studies scholars have established that individuals' learning and knowledge practices are critical for organisational learning and organisational knowledge. By integrating organisational learning, organisational knowledge, innovation theories and management perspectives into one research model, I contribute towards understanding innovation at more micro-levels (see Figure 10.1).

**Figure 10.1: Advancing multi-levels of analysis on the innovation system.**




Regarding research question 1 and the obstacles biotechnology firms face, philosophy of science scholars have theorised an increasing interaction among science policy, public science and private R&D changes debates about the direction and priority of science in the

society(Etzkowitz & Leydesdorff, 2000; Gibbons, et al., 1994). However, my co-author and I found:

- Private R&D and New Zealand universities continue to be reported using their traditional economic and scientific frames in the New Zealand national innovation system, and,
- The frames used to report public research organisations in the New Zealand national innovation system have diversified, but the extensiveness has fallen over the 15-year period (Callagher & Husted, 2010).

We argued these longitudinal trends suggest organisational actors who are central to developing New Zealand's biotechnology industry continue to act within their traditional fields of practice. The implications of these findings are that knowledge-based development efforts to influence the innovation system need to be analysed at lower levels of the innovation system where public policies are aimed, that is changing firms' processes and individuals' practices.

Studies of biotechnology clusters rarely consider the life-stage of the industrial cluster. This makes it difficult to draw inferences about innovation in newly emerging clusters, such as the Auckland one, from the existing literature because the characteristics of emerging clusters are different to those of growing, maturing and declining clusters (Menzel & Fornahl, 2010). Examining the obstacles faced by biotechnology firms (research question 1), this research provides qualitative evidence at the firm- and individual-level to support Menzel and Fornahl's (2010) theory that cluster life-stage influences innovation.

My study of biotechnology firms' responses to government attempts at facilitating a biotechnology industry in New Zealand found:

- Firms' communication channel use show firms' knowledge processes are influenced by what expertise is available in the emerging cluster.
- When expertise is locally available, firms use face-to-face communication channels. In contrast, when non-local-expertise is required firms access expertise through communication pipelines.

Understanding what learning opportunities are available to firms in emerging clusters is an important contribution towards explaining the consequences of cluster life-cycle stage for

innovation. Scholars have claimed that industrial clusters are important for innovation because they provide localised learning advantages (Malmberg & Maskell, 2006; Porter, 1998). However, my research suggests these general claims about industrial clusters need to be revised to reflect that firms' knowledge processes are influenced by cluster life-stage due to varying learning opportunities.

Not only are firms' knowledge processes influenced by cluster life-stage; individuals' practices are influenced too. To address research question 2 about influences on individuals' practices, my study of search practices compared individuals' search practices used in the emerging cluster with search practices reported from the literature on established clusters. The study found:

- Individuals adapt their search practices to access expertise depending on whether that expertise is available locally or not.
- The nature of individuals' experience influences search practices used for access expertise.

Also addressing research question 2 my fourth study of individuals' selection practices explored how the geographic and relational location of innovation combine to influence individuals' practices to select external expertise. The study found:

- When relational proximity and geographic distance are present, firms create geographic temporary proximity. This is sufficient because the existence of shared ways of knowing allows individuals to work together using communication technologies.
- When relational and geographic distance is present, firms create geographic proximity by moving individuals between countries. This is necessary because face-to-face communication is critical to individuals' selection decisions.

According to Coleman (1990) relating social phenomena, such as innovation, across levels of the system is a central problem in social science of explaining collective outcomes with individual action. To address this multi-level analyses of innovation systems need to be extended to include the micro-foundations of individual action (Nooteboom & Stam, 2008). By exploring firm-level communication channel use and individual-level search and selection practices, my research has contributed to understanding innovation at more micro levels of the innovation system.

### 10.3.1 Limitations.

A number of limitations must be declared about the research. First, as other scholars have noted there are particularities to biotechnology (Pisano, 2006b), which means the reader must be careful to draw direct comparisons between processes used by firms and practices used by individuals in the biotechnology industry with those used in other industries. Given the relatively high levels of uncertainty is a characteristics of the biotechnology industry the reader must consider whether the firm-level processes and individual-levels practices reported in the study are a feature of uncertainty.

Second, the interpretive approach used for this qualitative research means the reader must be careful to draw generalisations. Instead, the reader can judge the transferability (Merriam, 2002) of these findings by considering the similarity of other situations with the thick descriptions of the New Zealand national innovation system, the Auckland biotechnology cluster, biotechnology firms' communication channel use, and individuals' search and selection practices for accessing expertise.

Third, this study has focussed on firms operating in an emerging industrial cluster, so it is important for the reader to consider the characteristics of emerging clusters when comparing to other contexts. Furthermore, in comparing other clusters to the Auckland biotechnology cluster the reader must account for socio-political-historic factors that influence the direction and development of all industrial clusters.

## 10.4 Implications

The research has contributions for innovation and management scholars, and policy-makers. Establishing that individuals' practices are important to understanding innovation, scholars are a step closer to understanding how firms can actually manage their knowledge workers by understanding how the conditions they operate in effect their individual practices. In particular, firms' manage local and global networks because learning opportunities vary

across cluster life stage. Of course, this raises an interesting question for future research regarding how firms' change their network management as clusters evolve.

The role of individuals' practices raises important questions about the management of knowledge workers who operate across different knowledge domains. Recently knowledge governance scholars have argued that individual action is central to advancing organisational studies and management theories (Foss & Michailova, 2009). These findings suggest that knowledge governance explanations of innovation are also required to explain how informal governance mechanisms operating in knowledge domains interact with firms' governance mechanisms. Examining individuals' practices provides a theoretical lens to examine interactions between macro-level governance mechanisms and micro-level individual action.

Future research about network management across industrial cluster life-cycle stages and knowledge governance across knowledge domains also highlights in need to for more multi-level innovation research. In their recent review article Crossan and Apaydin (2010) argued that a multi-dimensional approach is required to advance innovation management research. My findings strongly suggest that a multi-level approach is required to appreciate aspects across the innovation system that influences firms' and individuals' practices.

The findings also have policy-making implications. While public policy can seek to facilitate innovation within emerging clusters, politicians and policy-makers need to keep in mind that it is necessary for biotechnology firms to engage in non-local learning and knowledge processes. These processes are important because they provide access to expertise that is essential to firms' innovation. This presents an important issue of how innovation policy can balance the need to support firms' current knowledge requirements with the need to facilitate clusters' ongoing development.

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