Small World, Big Ideas, and Smart Companies – A Qualitative Study of Academic Spin-off Companies and Knowledge Creation

by

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I wish to acknowledge the numerous scientists who I met during the course of my dissertation fieldwork. Whether in an incremental way or in great stride, the work that you do makes our world a better place. I laud the careers that you have chosen and wish that this dissertation strengthens our understanding of social factors that sustain efforts to keep science a noble pursuit for knowledge at its best.

The actual writing of a dissertation is a mentally laborious endeavour. Caffeine in the form of good coffee and tea and enjoyed in what sociologist Ray Oldenburg describes as a "third place" setting (i.e. a coffee shop) is a necessity to vagabond scholars like myself who travel everywhere with a laptop in tow and seek the company of other like-minded kindred spirits. For their nurturing of community and their procurement and presentation of good coffee, tea, and snacks, I am grateful for Sweetwaters, Zingerman's, Comet, Espresso Royale, and numerous other coffee shops in Ann Arbor. I also highly recommend Beezy's and the Ugly Mug in Ypsilanti; Bean and Leaf Cafe in Royal Oak; the Coffee Exchange in Windsor; Dark Horse Espresso Bar in Toronto; Intelligentsia Coffee and Argo Tea in Chicago; Peet's and the Coffee Bean and Tea Leaf in California; Stumptown Coffee in Portland; and the countless cafés scattered throughout Australia's major cities, which got me through my fieldwork. My dissertation may be finished, but the quest for finding good coffee will never end – so long as I have a laptop, new projects to work on, and people to meet.

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Abstract

This dissertation is about spin-off companies that stem from academic research activities from within universities. The focus is on the ways in which these companies create knowledge, the ways in which knowledge flows both within and outside of the company, and generally, the ways in which knowledge can evolve from an abstract scientific concept into an application that benefits society. The development of a more nuanced understanding of *organizational knowledge* and *organizational knowledge creation* in an academic-industrially situated context is an important aim of this dissertation.

The growing trends of academic research commercialization motivated this study. Universities are seen as agents of economic growth whose students, faculty, and researchers generate both incremental and breakthrough innovations through the knowledge they create. Some of this innovative output demonstrates commercial potential, which can underlie the organization of a new business venture whose aim is to further develop a proof-of-concept and a marketable product solution for the benefit of the greater good. Academic spin-off companies are business ventures and a category of social organizational architecture. They assemble both university-based and non-university-based intellectual and capital resources for the purposes of developing an academic research outcome into a practical product or solution. Various factors influence the organization of academic spin-off companies. Institutional factors such as the establishment of commercial and academic legitimacy influence the transparency of such companies, while epistemological factors such as diversity of knowledge resources influence their network structure and connectedness.

A qualitative case study of six Australian academic spin-off companies with international reach and connected to a common research university is the basis of this dissertation study. Each company is either a life science firm, a medical technology firm, or a firm with activities in these complementary industries. This dissertation adheres to the tenets of inductive theory building and seeks to contribute new middle range theoretical propositions and directions for future research to the growing body of scholarship on academic research commercialization and higher education. This dissertation draws from an interdisciplinary body of scholarship that includes organizations and knowledge, sociology and networks, entrepreneurship and new business development, and higher education policy.

Chapter 1 – Introduction

Introduction

Overview and research questions

This dissertation is about spin-off companies that stem from academic research activities from within universities. The focus is on the ways in which these companies create knowledge, the ways in which knowledge flows both within and outside of the company, and generally, the ways in which knowledge can evolve from an abstract scientific concept into an application that benefits society. The development of a more nuanced understanding of *organizational knowledge* and *organizational knowledge creation* in an academic-industrially situated context is an important aim of this dissertation.

The research unfolds to reveal a process in which academic spin-off companies navigate epistemological and institutional terrain – as determined by each company's respective goals and strategies. The ways in which they navigate this terrain affects the ways in which they create, disseminate, and transfer knowledge. This research takes an organizational level of analysis in that it considers knowledge as something possessed by individuals but situated and amplified in organized contexts. As such, universities are organizations that assimilate individuals and enable them to create knowledge in an academically situated context. Spin-off companies are organizations that assimilate individuals who possess academically intensive knowledge and situate them to create new knowledge that yields practical innovative outcomes for the benefit of society. Druilhe and Garnsey (2004) note that there is very little research into academic spin-off companies from the organizational level of analysis. They note that this is a field of academic research that is in its infancy.

The research questions to be addressed are:

- *How do academic spin-off companies create knowledge?*
- *What roles do universities play in the creation of knowledge by academic spin-off companies?*

A conceptual definition of academic spin-off companies

An academic spin-off company is a category of social architecture that describes efforts to organize collective practices in an academic-commercial inter-institutional setting for the purposes of advancing project specific and goal oriented research and development activities. Consequently, academic spin-off companies may resemble a variety of archetypical or template-based organizational structures (Greenwood and Hinings, 1996) including that of a hierarchical and multi-divisional firm (Chandler, 1977); a virtual company that exists as a box of contracts, which dictate the expectations and actions of its members (Davis, 2009; Handy, 1995); or an informally-organized community of practice, which is loosely-coupled, ambiguously-bounded, and managed around the rhythm of specific projects (Bauer, 2007; Powell and Grodal, 2005; Wenger and Snyder, 2001). Because academic spin-off companies are organizations of embedded research and development (R&D) activities, they play an important role as knowledge hubs that assimilate diverse insight and expertise from academic and commercial-industrial networks (Gittelman and Kogut, 2003). The assimilation of insight diversity enables them to organize and create knowledge.

A critical feature of academic spin-off companies is that they exist at the institutional boundary of the academic community and the commercial marketplace. Consequently, the knowledge that is constructed within them and that is disseminated and transferred beyond them is limited by the requisite levels of academic and commercial institutional legitimacy, as determined by the varying goals and strategies of each company.

A conceptualization of knowledge

Tsoukas and Vladimirou (2001) underscore that "knowledge is a tricky concept" (p. 975). The authors arrive at an intelligible argument that knowledge is both personal and collective. It is personal in that knowledge involves a *knower* – an individual with an intellect who can construct meaning of something. Yet it is collective in that it is embedded in contexts of organized individuals. Knowledge is socially constructed in that knowledge is "developed, transmitted, and maintained in social situations" (Berger and Luckman, 1966, p. 3). Networks represent connections among people and the knowledge embedded within those connections (Ogle, 2007). On the one hand, people can experience relatively closed and redundant networks in which they routinely encounter the same people and ideas, which can reinforce existing knowledge (Coleman, 1990, 1988). On the other hand, people can experience relatively open and non-redundant networks in which they routinely encounter new people and new ideas (Burt, 1992; Granovetter, 1973). In essence, knowledge resides in the mind of the individual as well as the "collective mind" of broader social structures. For the organizational researcher, an understanding of social structure and how it embeds collective intelligence is a practical starting point for determining where knowledge is situated (Patriotta, 2003).

Personal and collective distinctions refer to the situating of knowledge in context – the ways in which people go about their daily routines and intelligently act as one or as many (Patriotta, 2003). However, when dealing with distinctions about knowledge itself, this dissertation relies on a practical differentiation that is rooted in much of the scholarship about knowledge and organizations. Among the most commonly cited variance in the nature of knowledge is the distinction between *tacit knowledge* and *explicit knowledge.* Scholarship often identifies tacit knowledge as the deep know-how that we cannot often articulate, but that which affects our actions (Nelson and Winter, 1982; Polanyi, 1969). Explicit knowledge is that which can be codified and is often synonymous with *information.*

The organization of tacit knowledge involves social processes because it entails the assimilation of knowledge that is individually possessed by way of the people who possess it. Thus, tacit knowledge is collected and organized when people organize. The organization of tacit knowledge equates to the organization of experience and deep know-how that is difficult to separate from the knower but can be amplified and elicited through social interaction and manifested as collective meaning, action, and routines.

In contrast, explicit knowledge can readily exist independent of an individual because, by definition, it exists in codified form (Brown and Duguid, 2000). As an illustration, a book is a form of explicit knowledge that has been codified as written words. Yet individuals construct meaning from these written words and possess tacit knowledge that they derive from this meaning. An organized setting such as a class at a university can assimilate individuals who each have independent tacit knowledge about the meaning they derive from the book and amplify this knowledge through discussion. As a result, organized collective meaning is reached, and the class is said to possess collective knowledge.

Academic research commercialization

Spin-off companies as academic research commercialization

The scholarship on academic spin-off companies spans multiple disciplines and perspectives. In the field of higher education, academic spin-off companies are viewed as a form of *technology transfer.* As a whole, technology transfer is considered part of a larger discussion of *academic research commercialization* (also referred to as *academic capitalism*). See Figure 1.1 on the following page for a venn diagram representation of this relationship.

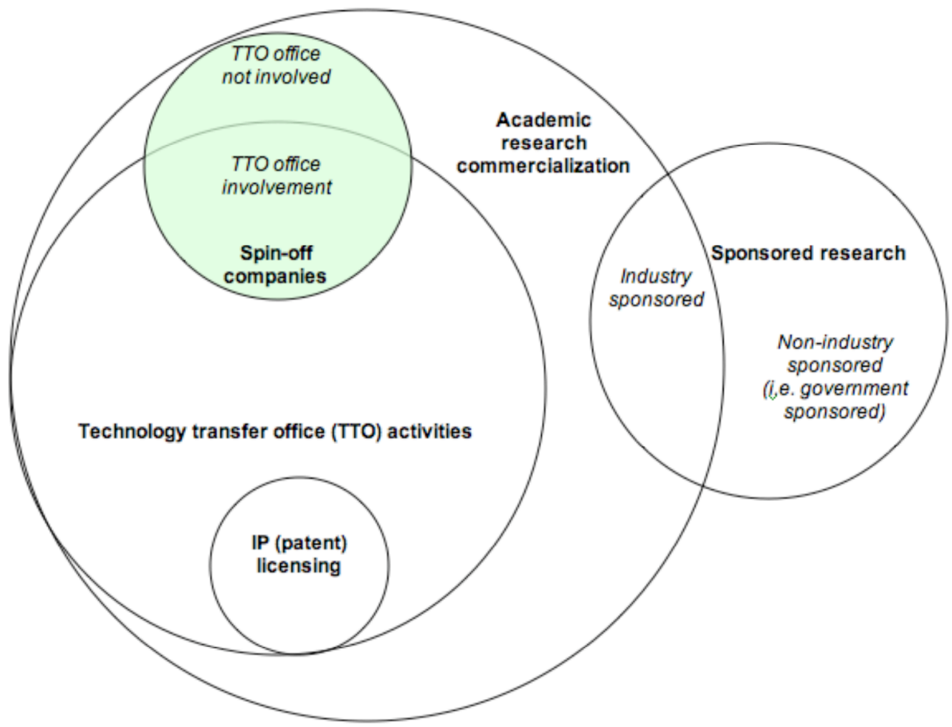

Figure 1.1 – Relationship of academic spin-off companies to the issue of academic research commercialization

Academic research generally refers to the work of universities and their faculty, graduate students, and post-doctoral scholars. *Commercialization* refers to economic market processes as a means of dissemination and transfer of academic research. The specific actions associated with academic research commercialization commonly, but not exclusively, involve university technology transfer offices (TTO's). Typical TTO's are units in university organizations that license university intellectual property to other organizations, engage in business development activities related to the establishment of new companies based on academic knowledge, cultivate and maintain industry contacts. Individual scientists sometimes “go it alone” and engage in their own commercialization activities. As such, academic research commercialization activities can occur outside of institutionalized TTO’s or other formalized university channels. This dissertation will highlight examples of academic research commercialization that occurred through the formation of spin-off companies in which variability exists around the extent to which formal TTO channels played a role.

Existing scholarship has examined various aspects of the commercialization of academic research. This long line of research has focused on such aspects as the patenting of university research findings as intellectual property (e.g. Mowery, Nelson, Sampat, and Ziedonis, 2004); the licensing of intellectual property to companies (e.g. Thursby and Thursby, 2007; Shane, 2004; Owen-Smith and Powell, 2003); the publication of research as an aspect of knowledge transfer (e.g. Agrawal and Henderson, 2002; Zucker, Darby, and Armstrong, 2002); individual academic entrepreneurs (e.g. Krabel and Mueller, 2009; Mosey and Wright, 2007); the launching of companies from university research (e.g. Golob, 2006; Druilhe and Garnsey, 2004; Murray 2004); and other informal knowledge sharing activities with industry (e.g. Link, Siegel, and Bozeman, 2007).

Practical characteristics of academic spin-off companies

As pictured in figure 1.1, the establishment of a new company based on academic research can occur both within and outside university technology transfer channels. In existing research, this distinction is evident in the terms *academic <u>spin-off</u>*

company and *academic start-up company*. The former is an entity that is established through TTO channels, while the latter is an entity that individual scientists or entrepreneurs establish through their own efforts. The common denominator is that both *spin-off companies* and *start-up companies* utilize commercial means to establish a new company based on academic knowledge with the objective of building a business enterprise around that knowledge that yields innovative outcomes.

My interest in this dissertation is the exploration of companies that academic scientists founded through their academic research efforts, regardless of the role that the university played in their establishment. Throughout this dissertation, I will use the term *academic spin-off company*. Despite a belief at the onset of the study that the companies in my sample were all 'spun-off' from a common university TTO, my research unfolds to demonstrate a wide variation of the university's role in the launch of new companies. In a recent literature review of academic spin-off companies, Djokovic and Souitaris (2008) suggest that the link among academic research commercialization, spin-off companies, and knowledge theory is a ripe area for investigation. Because knowledge originates from people, my interest starts with the people who are the originators of academic knowledge and subsequently flows into the organization of multiple people and the ways in which these groups of people use the establishment of companies as a means of situating and advancing their knowledge.

Some academic scientists are more commercially experienced than others. Additionally, some universities produce more spin-off companies than others. Research tends to indicate that these two factors are not always mutually exclusive. Scientists who are commercially experienced tend to have a higher frequency of industry contacts through their respective academic departments and disciplines than those who do not. They also tend to come from universities that emphasize collaboration with industry. Elite wealthy universities such as Stanford, MIT, and Harvard produce a disproportionate number of spin-off companies compared to other universities (Zhang, 2009). University cultures, norms, and practices influence the extent to which faculty engage in entrepreneurial activity and launch spin-off companies based on their research (Zhang, 2009; Kenney and Goe, 2004).

Academic spin-off companies are descriptively heterogeneous (see Wright, Birley, and Mosey, 2004). They span numerous industries – including biotechnology, nanotechnology, medical technology, information technology, alternative energy, and materials. Their ties to the university from which they emerged vary. The founding scientists sometimes remain involved in the new venture. In other cases, the technology is licensed to a third party start-up company that has no relationship to the university or the founding scientists. Financial structures also vary. Private venture capital firms invest in some companies. Other companies are funded by individual high-net worth investors. Some universities and government entities provide early stage funding for these companies. In other cases, individual scientists self finance the new company. Company goals and strategies vary. Some academic spin-off companies are organized to raise money for long-term R&D projects that show long-term commercial potential. In contrast, other companies are organized to immediately commercialize a knowledge based service or technology. A consequence of this variation, the organizational architecture varies among academic spin-off companies, which ultimately affects the ways in which they create knowledge.

Universities and the organization of knowledge

It is important to recognize the origins of academic spin-off companies as rooted in academic knowledge. The broader academic community of higher education as a social institution is its formal organization around knowledge. As Clark (1983) notes, “For as long as higher education has been formally organized, it has been a social structure for the control of advanced knowledge and technique” (p. 11). Universities play a leading role as a knowledge arbiter and legitimizer (Stevens, Armstrong, and Arum, 2008). They define how knowledge is categorized as well as what counts as legitimate knowledge (Geiger and Sá, 2008). Gumport and Snydman (2002) note, “Postsecondary organizations are a primary societal arena in which knowledge is developed. That is, universities and colleges both reflect and reconstitute classifications of knowledge and in so doing establish categories of expertise and knowledge worth knowing” (p. 376).

The academic institution organizes knowledge across a variety of bureaucratic and epistemological categories – among them are *disciplines, degree programs, schools of thought, paradigms, invisible colleges,* and *professional societies* (see Gumport and Snydman, 2002; Allen, 1997; Swidler and Arditi, 1994; Crane, 1972; Kuhn, 1970 for explanations of each). These categories reflect the organization of people engaging in academic activities, while other categories reflect the organization of ideas and knowledge that are the result of academic activities. Some categories are more meaningful and distinct than others. For the purposes of this dissertation, these categories are meaningful to the extent that they are meaningful to the organizations and the organizational actors that are the subject of this research.

The commercialization of academic research represents a form of knowledge dissemination in which academic knowledge is transferred from an abstract form (such as in theories or formulae) into a practical form (such as a new technology or practice). Universities play a unique role as a source of abstract concepts but generally do not possess the capabilities for converting abstract concepts into practical ends. Likewise, the commercial sector is limited in its ability to conduct basic research and create abstract knowledge (Stankiewicz, 1986). Rosenberg and Nelson (1996) argue that university researchers are not articulate in product markets while the dwindling number of corporate research laboratories dedicated to the most basic research seldom achieve results that justify the direct investment of resources for that research, which results in a division of labor between the academic community and the commercial sector (see also Pisano, 2006). Similarly, Matthews and Norgaard (1984) argue that an area exists between the process of conducting basic research (the area in which universities excel) and the process of development and production (the area in which business firms excel) that offers collaborative opportunities between academe and the commercial sector. As a result of these differences, commercialization of academic research offers an opportunity for academic knowledge to undergo a transformation of function from an abstract concept to a practical innovation.

Cross-institutional boundaries between higher education and industry

The increased levels of activities that span the university-situated institution of higher education and the corporation-situated institution of industry necessitate studies that are sympathetic to these inter-institutional differences. Brimble (2007) articulates these inter-institutional differences:

> Universities and industries have different time frames, different cultures, and different motivations. Their understanding of knowledge, the knowledge-generation process, and the knowledge-use process differs greatly. The challenge is to bridge the gap – to enhance the common understanding of what each side has, what each side wants, and what each side needs (p. 273).

Individuals who engage in academic research commercialization routinely straddle the institutional boundaries between higher education and industry. Sometimes, certain characteristics clearly demarcate the boundaries between higher education and industry. For example, the Palo Alto Research Center (PARC) is an industry research center, which is owned and operated by Xerox. Despite its location in the Silicon Valley region, PARC had a long history of isolation and an inward culture in which its activities were notably withdrawn from other activities in the region – especially from activities that involved collaboration with the region's universities (Ogle 2007; Brown and Duguid, 2000; Saxenian, 1994). Likewise, Harvard University historically maintained a culture of relative isolation from the industries of the Boston and Cambridge areas and remained highly focused on academic interests (Saxenian, 1994). Sometimes, certain activities and organizations blur the boundaries between higher education and industry. The biotechnology industry is a particular example of an industry that is highly embedded in the academic community (Liebeskind, Oliver, Zucker, and Brewer, 1996). In some cases, biotech companies organize like *quasi universities* and sponsor post-doctoral researchers as well as contract various research activities to universities (Lynskey, 2006; Pisano, 2006; Stuart and Ding, 2006; Powell and Owen-Smith, 1998).

Both higher education and industry engage in research activities. Likewise, certain characteristics blur the boundary between academic and industrial research activities. Sometimes this boundary is delineated between the so-called distinctions between the *basic* (or *fundamental* or *pure*) research conducted in universities for the advancement of knowledge for its own sake and *applied* (or *practical*) research conducted in industrial settings for the advancement of a specified commercial end. While, Rosenberg and Nelson (1994) describe this division of labor between the boundaries of academic and industrial research, Slaughter, Archerd, and Campbell (2005) argue that the work of individual university scientists sometimes blur these boundaries in that academic work can be used for commercial gain, and commercial work can have an academic component. They argue that academic scientists often negotiate a variety of tensions when navigating the boundaries between the academic and commercial worlds of their research activities – namely the tension between the open publishing of research and the protection of research as intellectual property; the tension between research secrecy and research openness; and tension around the determination of intellectual property ownership rights. With respect to academic spin-off companies they argue that individual scientists negotiate these tensions and that the involvement of individual scientists in companies reflects funding source quandaries (the availability of government research grants against the availability of corporate research grants) as well as institutional mission quandaries (the university as an agent of economic growth or not) that they face.

The concepts of *boundary spanning* (interactions across clearly demarcated boundaries between higher education and the commercial environment) and *blurring* – or *blurred – boundaries* (interactions across ambiguously demarcated boundaries between higher education and the commercial environment) are key background concepts in this dissertation. To some extent, academic scientists who are involved in spin-off companies based on their knowledge and research activities span both the higher education and industrial boundaries. However, the activities of these companies tend to vary to the extent to which their individual boundaries are distinct from or blurred with the university community.

The multi-faceted mission of the university and its role in society

One specific area of inquiry within the study of higher of education addresses the issue of the merits, drawbacks, and implications of academic research commercialization, which therefore extends to the phenomenon of the launch of a spin-off company as a form of research commercialization. Academic research commercialization, in part, stems from the wider debate about the role of university in society. The commercial aspects of the university research “product” are concerned with its concrete utility. In contrast, research that is “pure” is considered free from any outside influence into the purpose or desired outcome. The educational philosopher John Dewey (1933) wrote in *How We Think,* about the need for educational systems to strike a balance between the utilitarian and non-utilitarian ends of their philosophical spectrums. As such, commercialization can be considered as a utilitarian aspect of the institution of higher education.

> The educational end is not the destruction of power to think practically in overcoming obstacles, utilizing resources, and achieving ends; it is not its replacement by abstract reflection. Nor is theoretical thinking a higher type of thinking than practical. A person who has at command both types of thinking is of a higher order than he who possesses only one. Methods that, in developing abstract intellectual abilities, weaken habits of practical concrete thinking fall as much short of the educational ideal as do the methods that, in cultivating ability to plan, to invent, to arrange, to forecast, fail to secure some delight in thinking, irrespective of practical consequences (pp. 227-228).

Academic research commercialization is rooted in the notion that universities and their researchers and scientists should create knowledge that enriches society with practical benefits. It follows Boyer’s (1990) definition of the *scholarship of application*, or the responsible application of knowledge to consequential problems through which new intellectual understandings can emerge. It is one important role among others that

Boyer describes a university as playing (he also describes the scholarship of integration, the scholarship of discovery, and the scholarship of teaching). Academic research commercialization is a form of *engaged scholarship* (Van de Ven, 2007) in that it moves beyond the scope of research as an end and involves the stakeholders of research (researchers, users, clients, sponsors, and practitioners) to determine ways that research can be a consequential means to a practical end. Similarly, Greenwood and Levin (2001) write about *action research* as a model of academic research in the 21st century. They write:

> The pragmatic approach involves a change in the boundaries between the university and the rest of society because to work this way demands that the academic researchers and society's users or stakeholders work collaboratively in a co-generative knowledge construction process to resolve their problems. This is why we envisage action research as the way universities should increasingly operate (Greenwood and Levin, 2001, p. 435).

Despite the debate around the utility of research, the motivation for conducting research, or the supporting factors of research, research is a process driven in the pursuit of creating new knowledge. This dissertation is not designed as a study whose results are intended to enter the debate on the issue of academic research commercialization. Its central aim is to investigate aspects of the phenomenon of knowledge creation. Universities have individual missions, possess individual resources, and face a variety of individual constrains throughout their individual efforts to serve the public good. The issue of a university's role as an agent of the public good is forcing universities to reevaluate the extent to which academic research commercialization is central to their respective missions (Geiger and Sá, 2008). Therefore, individual universities are in the best position to determine how to best serve the public good, as defined by the "public" that they serve.

Universities as agents of economic growth

A significant body of policy literature recognizes the importance of the systemic relationship between universities and the commercial sector and the impact that the relationship has on economic growth. Much of this stems from the economic development potential that rests in university-commercial relationships. Knowledge spillover from universities to companies and the formation of knowledge clusters matters to local leaders concerned with economic development (Geiger and Sá, 2008; Foray, 2007), and the relationship between university knowledge spillover and regional innovation cluster performance has been explored using various methods, including analytical (e.g. Rothaermel and Ku, 2008) and ethnographic methods (e.g. Saxenian, 1994). Research universities and their associated research parks are often indicative of economic development in the communities in which they are located (Geiger, 2004; Caniëls, 2000).

Some of these research parks or local innovation clusters consist of spin-off companies created when university researchers decide to start new companies with the fruits of their research (Shane, 2005), and some researchers feel that spin-off formation is an important extension of their academic role (Crespo and Dridi, 2007). This university-stimulated economic development can lead to new job growth at existing companies as well as overall regional prosperity and national competitiveness in the global marketplace (Carlsson and Fridh, 2002; Wilem, 1991). These trends encompass what Graff, Heiman, and Zilberman (2002, p. 88) define as the "educational-industrial complex."

Criticism of academic research commercialization

The subject of academic spin-off companies emerges amidst some wider criticism of corporate research commercialization trends and corporate influences on higher education (Zusman, 1999). Rhoades and Slaughter (2004) refer to *academic capitalism* as a sweeping trend in higher education in which universities seek to generate revenue from their education, service, and research functions. Academic research commercialization and the specific notion of academic spin-off companies fall under this rubric. Some of the critics of academic capitalism argue that faculty members are becoming "too corporate" while forgoing academic values (e.g. Etzkowitz, 1999; Campbell, 1995; Rhoades and Slaughter, 1991). Others point to various conflicts of interest between universities and businesses and such mutual activities as sponsored research and technology transfer (e.g. Bok, 2003; Campbell and Slaughter, 1999; Campbell, 1995, Allen and Norling, 1991; Powers, et al., 1988; Stankiewicz, 1986). Finally, others argue that university-industry relationships will compromise research quality, impinge on academic freedom, and lead to overly practical research agendas (e.g. Washburn, 2005; Bok, 2003; Liebeskind, 2001).

A powerful counterargument positions the university as having never been so "pure" in its relationship with industry as well as with other sources of financial support. Several prominent American universities such as MIT, Caltech, and Carnegie Mellon have industrial ties that date to the founding of their institutions (Thelin, 2004; Servos, 1994). Sample and Bennis (2003, July 13) argue in the *Los Angeles Times* that university-industry relations represent "a virginity within American higher education that was lost long ago." Similarly, Kleinman and Vallas (2001) write,

> Some critics of UIRs (university-industry relations) draw attention to the dangers implied by the commercialization of the academy, often seeing this tendency as a novel departure from the purity and innocence of the idyllic university. We suggest that this stance is misleading, for it perpetuates mythical conceptions of the historical relations among knowledge, power, and patronage (p. 479).

This dissertation was not conceived to directly address this specific issue. However, as a researcher in an education program of study, I am not blind to this debate. Because my interest in this research was the phenomenon of knowledge creation, I sought to remain agnostic in my research design and overall scholarly perspective. Knowledge and knowledge creation matter to academic spin-off companies regardless of one's position in this debate. Furthermore, this dissertation is less concerned with matters of technology transfer – which tends to focus on policy implications – and is more concerned with matters of knowledge, the people involved in its creation, and the mechanisms of organization that assemble it, situate it, amplify it, and transfer it.

The central argument

Overview

John Seely Brown and Paul Duguid (2000) argue in their book, *The Social Life of Information,* that information and knowledge is embedded in broader social contexts and that technology alters and shapes the context through which information is transferred and knowledge is created. They frame their argument at the beginning of the Internet revolution when people were coming to terms with the explosive growth in information access and connectivity. In a similarly insightful book – *Smart World* – Richard Ogle (2007) argues that the broader social context (for example, in institutions, practices, myths, paradigms, and even technology) is an extension of the human mind, which situates and amplifies individual intelligence and is responsible for humans' ability to achieve creative breakthroughs. Polanyi (1969) argued that knowledge requires a knower, which indicates a human mind. Individuals acquire information, process it, learn, and build individual knowledge and intelligence. However, the world and the societies that exist within it is the context that allows individuals to make meaning. Collective interaction yields insight that extends beyond that which an individual could produce.

This dissertation asks a straightforward question – *how do academic spin-off companies create knowledge?* The "simple" answer is that academic spin-off companies assimilate and embed knowledge, which reflects a navigation of epistemological and institutional terrain as determined by each company's respective goals and strategies. In doing so, companies update and refine existing knowledge through iterations of solutions, critiques, and modified solutions, which address their stated goals. The research presented in this dissertation demonstrates that these companies negotiate epistemological and institutional terrain in various ways, which ultimately reflects the construction of their respective social structures. The richness of this study is rooted in the variability and consistency through which the social structures are created.

Patriotta (2003) argues that the study of organizational knowledge should begin with a consideration of where people find themselves. In my study, people are found at the institutional boundary between the academic community and the commercial marketplace. Consequently, this institutional situation matters to the extent that it reflects the ways in which knowledge is assembled, created, legitimized, and disseminated.

Epistemological diversity and variability in social architecture

A practical challenge whose solution demonstrates commercial potential motivates the founding off academic spin-off companies. An innovative outcome is the ultimate goal of an academic spin-off company in the sense that each one seeks to develop and market a novel solution to a problem or challenge. Because of their orientation toward finding and marketing a solution to a problem or challenge, academic spin-off companies are organized to the extent that they are flexible enough to assimilate the requisite knowledge, skills, and insight for strategically addressing the solution or problem. Consequently, many academic spin-off companies strategically entail epistemological diversity as well as cross-disciplinary and cross-institutional collaboration. For example, an academic scientist who launches a company in order to develop a drug treatment for a specific disease has the flexibility to assimilate the requisite expertise for doing so. It does not matter if the expertise crosses defined disciplinary boundaries of academic organization. Consequently, academic spin-off companies are assimilators of knowledge.

Because of the variability in the goals and strategies of each academic spin-off company as well as the variability in sources of requisite expertise and other knowledge resources for addressing each company's practical challenge, academic spin-off companies vary to the extent of their social architecture. Organizationally, academic spin-off companies can assume the shape of hierarchical firms with divisions of labour; they can resemble communities of practice with some defined roles but with informality that reflects the rhythm of specific projects; and they can virtually organize as a loosely-coupled confederation of scientists. Despite this variation in the social architecture of academic spin-off companies, they are consistent to the extent that they assimilate knowledge from extended networks, which enables them to make creative leaps that yield new innovations.

Epistemological factors affect the coupling of academic spin-off companies to partners that provide access to other sources of knowledge, insight, and expertise. The extent to which an academic spin-off company seeks to diversify the knowledge that it assimilates will drive the extent to which the company collaborates with other individuals and organizations.

Multi-institutional terrain of academic spin-off companies

Academic spin-off companies exist at the intersection of multiple institutions, each with varying sets of norms and practices. These various institutions both facilitate and constrain the activities of academic spin-off companies, which affect the creation of knowledge. The academic institution of higher education impacts academic spin-off companies through its ability to legitimize the knowledge that they create. Its impact is also evident through the ways in which universities, in some cases, facilitate the activities of academic spin-off companies by providing them with resources and, in other cases, constrain the activities of academic spin-off companies by withholding or not having requisite resources.

The industrial environment and the broader commercial market economy are other institutions that affect academic spin-off companies through the resources that they provide or fail to provide. In many cases, the R&D activities of academic spin-off companies are costly and require an infusion of financial capital that industry is often in the best position to provide. Yet the market mechanisms that provide academic spin-off companies with capital also constrain their activities if the activities fail to demonstrate revenue-generating and profit-making rationales. Thus, academic spin-off companies face the pressures of maintaining legitimacy as a commercial enterprise.

Institutional factors affect the transparency of academic spin-off companies and the differences in their relationships to the academic and commercial sectors. Because of the inter-institutional nature of academic spin-off companies, the academic and commercial sectors are both responsible for bestowing legitimacy on them. Many of the institutional norms and practices of the academic community focus on openness and the relative unrestricted dissemination of knowledge. In contrast, many commercial sector norms and practices focus on restricting the sharing of information and the dissemination of knowledge. As organizations whose activities involve the assimilation and creation of knowledge, academic spin-off companies face a delicate balance with respect to their transparency around knowledge.

Organization of this dissertation

Literature review

The second chapter of this dissertation will offer a review of relevant scholarship around the key concepts that underlie the research. This chapter will elaborate on the concepts and ideas discussed in the overview of the central argument, which was in the previous section of this chapter. Chapter two is divided into four major sections, which ultimately build toward the conceptual framework, which will guide the empirical study.

The first section will cover overarching aspects of academic spin-off companies and the ways in which they determine their respective goals and strategies as well as how goals and strategies relate to the differences in the organizational social architecture. Academic spin-off companies are a category of social architecture that embeds knowledge. This section explores the variability of academic spin-off company social architecture and how they adhere to a variety of archetypical organizational forms, including formal hierarchical firms, communities of practice, and virtual companies. The second and third sections will discuss various factors that impact this social architecture. The second section will discuss epistemological factors such as the integrative power of novel combinations of knowledge. The third section will discuss the multi-institutional terrain of academic spin-off companies. It discusses how the higher education academic institution and the commercial sector legitimize academic spin-off companies and how these competing factors of legitimacy coincide with knowledge creation. This section describes the ways in which academic spin-off companies negotiate this institutional terrain. The fourth section will discuss the ways in which knowledge is created and the extent to which goals and strategies drive knowledge creation.

Research design

The third chapter of this dissertation will cover the overall research design of my study. It will cover the various aspects of the qualitative methodology that I employed, including a justification of the study's case study methodology as well as an explanation of the research setting. The chapter will also describe the ways in which I approach theory construction, and it will explain my position as a scholar in the context of my research setting.

In order to address the research questions proposed at the beginning of this chapter, I employ a qualitative case study design. My dissertation is a study of six academic spin-off companies whose founders share a common tie with the academic community of a large Australian research university (hereafter referred to as the pseudonym, *University of the Southern Hemisphere*). I constructed my sample through a site visit to the University of the Southern Hemisphere's technology transfer office. I conducted fieldwork in residence in Australia over the span of one month during which time I interviewed multiple academic scientists, managers, and venture capital professionals affiliated with each of the companies in my sample. I used document data to supplement my interview data and enrich my company case studies.

Chapter four provides the reader with additional context for the case studies. This chapter introduces the reader to the context of academic research commercialization in Australia as well as the supporting context of the Australian venture capital sector. It introduces the university technology transfer office and provides a general background for the office's evolution in support of academic research commercialization in the context of these cases. Finally, the chapter provides brief overview summaries of the six case study companies and includes basic descriptive characteristics of each one.

Research findings and summaries

Chapters five, six, and seven explore each of the six case study companies in-depth. Two companies are explored in each chapter, and the chapters are organized around similarities in organizational architecture. Chapter five discusses two companies in my sample that are organized as virtual companies. Chapter six discusses two companies in my sample that are organized as communities of practice. Chapter seven discusses two companies that are organized as hierarchical firms. These organizational differences offer meaningful distinctions among the companies in my sample. The goals and strategies of academic spin-off companies vary and impact the organization of each company's practices. Cases will be presented in narrative form in each chapter and will discuss the goals and strategies of each company, the epistemological and institutional variables that impact the work that they do, and they will discuss the ways in which each company creates knowledge. The relationship between each company and the academic community will further underlie the analysis in each chapter. Each chapter will conclude with relevant summaries of the similarities and differences among the companies.

The eighth chapter of the dissertation will offer final conclusions and will integrate these conclusions with directions for future research. It will illustrate the dissertation's contributions to several streams of inquiry, including the study of higher education, the study of knowledge, and the study of academic research commercialization.

Chapter 2 – Literature Review

Introduction

This chapter presents a review of relevant scholarly literature that drives this study of academic spin-off companies and knowledge. An academic spin-off company is a category of social architecture that describes efforts to organize collective practices in an academic-commercial inter-institutional setting for the purposes of advancing project specific and goal oriented research and development activities. Consequently, academic spin-off companies may resemble a variety of archetypical or template-based organizational structures (Greenwood and Hinings, 1996; DiMaggio and Powell, 1991) including that of a hierarchical and multi-divisional firm (Chandler, 1977); a virtual company that exists as a box of contracts, which dictate the expectations and actions of its members (Davis, 2009; Handy, 1995); or an informally-organized community of practice, which is loosely-coupled, ambiguously-bounded, and managed around the rhythm of specific projects (Bauer, 2007; Powell and Grodal, 2005; Wenger and Snyder, 2001). Because academic spin-off companies are organizations of embedded research and development (R&D) activities, they play an important role as knowledge hubs that assimilate diverse insight and expertise from academic and commercial-industrial networks (Gittelman and Kogut, 2003). The assimilation of insight diversity enables them to organize and create knowledge.

A critical feature of academic spin-off companies is that they exist at the institutional boundary of the academic community and the commercial marketplace. Consequently, the knowledge that is constructed within them and that is disseminated and transferred beyond them is limited by the requisite levels of academic and commercial institutional legitimacy, as determined by the varying goals and strategies of each company.

When the founders of an academic spin-off company elect to organize as a new entity through some degree of separation from the formal organization of the university, the founders enact a new social space for addressing the specific problem or opportunity that their company represents. Some scholars have argued that organizations *enact* rather than *react* to the broader environment and, consequently, form a stronger connection with the broader social context, and play a role in shaping the society in which they exist and the world at large (Kanter, 2008; Worline and Quinn, 2003; Weick, 1969; Argyris, 1964). Academic spin-off companies represent the passions of their founders who choose to use academic research and the knowledge to make the world a better place by accelerating the development of an innovative outcome that addresses a practical societal need.

Academic spin-off companies and organizational architecture

Goals and strategies of academic spin-off companies

The goals and strategies of academic spin-off companies widely vary. Each individual company has a unique goal – for example the development of a new drug or the marketing of a piece of new technology. Strategies for achieving goals vary, but companies with similar goals tend to mirror one another's strategies. Many academic spin-off companies are R&D intensive and are organized as mechanisms for the funding of long-term R&D projects. As a result, many don't earn revenue when they are initially founded and, subsequently, might only earn revenue and a profit when they successfully solve their respective challenge. However some spin-off companies are immediately able to commercialize knowledge in the form of a specific technology or solution when they are founded. Because of these inherent characteristics, academic spin-off companies typically make decisions about their short-term and long-term objectives, which is an important aspect of strategic *ambidexterity*.

Organizational ambidexterity (Tushman and O'Reilly, 1997, 1996; Gibson and Birkinshaw, 2004) is rooted in a resource-based view of the firm in that it applies to the diversity of assembled resources that enable an organization to react to and adapt to change, enact the environment in which it exists, and survive. The concept of applies here because the "resources" of an organization that make it "ambidextrous" includes knowledge resources. Nonaka and von Krogh (2009) define ambidexterity as an organization's ability to successfully "achieve a balance between being efficient in running today's business, while being adaptive to changes in their environment ensuring that they also survive in the future" (p. 647), and they argue that knowledge enables a firm to become ambidextrous.

The concept is rooted in March's (1991) article about *exploration* and *exploitation* strategies in that organizations should balance both types of activities (Simsek, Heavey, Veiga, and Souder, 2009). According to March, organizations should balance the competing demands of exploring new possibilities and exploiting old certainties. As such, organizations can explore new knowledge and exploit existing knowledge resources. According to March (1995), organizations in a rapidly changing world benefit from the adaptability that the balance of exploration and exploitation provide.

For many companies, the balancing of exploration and exploitation is a strategic decision that drives their ability to innovate (Bierly and Daly, 2007; He and Wong, 2004). Some academic spin-off companies are launched as a means of raising commercial funds for R&D projects that show the potential of yielding a breakthrough innovation over the long-term (an exploration strategy). Other academic spin-off companies emerge as a mechanism for immediately commercializing a technology (an exploitation strategy). Each company faces strategic decisions of whether or not to diversify their activities. The company that is founded with an exploitation strategy may need to invest in explorative projects that diversify its knowledge base and increase the chances of developing future innovations. The company that is founded with an exploration strategy may need to pursue some exploitative tactics in order to raise additional revenue. In any case, the balancing of exploration and exploitation will increase the level of activity that occurs within the company and enable more learning opportunities that produce knowledge.

Strategically, academic spin-off companies balance exploration and exploitation activities. Doing so affords them a degree of ambidexterity and enables them to balance the competing demands of capitalizing on the knowledge resources that are presently available to them and developing new knowledge resources over the long term. Academic spin-off companies evolve into a variety of organizational forms that enable them to most effectively balance the demands of exploration and exploitation and to ultimately address the problems and challenges that they are organized to address and whose solutions will provide them with short term or long term commercial benefits.

Variations in the organizational architecture of academic spin-off companies

The specific goals and strategies – and ultimately the specific challenges, threats, and opportunities – of individual academic spin-off companies vary. Consequently, the organizational architecture of academic spin-off companies varies. Stinchcombe (1990) notes, "The social structure of organizations can be explained by the structure of the information problem they are confronted with" (p. 29). His argument about the variance of knowledge-centric challenges and the ways in which they coincide with variance in organizational structure is relevant to my study of academic spin-off companies. Academic spin-off companies with similar goals, strategies, opportunities, threats, and challenges organize practices in similar ways.

Some scholars have attributed the similarities and differences in organizational structures to *archetypes*. Greenwood and Hinings (1996) note that an organizational archetype is a template of collective behaviour that reflects convergence around taken-for-granted assumptions about work. Similarly, Bauer (2007) notes, “Organizations shape what individuals pay attention to or ignore, what they care about, desire, despise, or fear, what they fight for or let go of. Organizations are epistemological devices guiding individual perception, sensemaking, valuing and, most of all, choice and action” (p. 37). Academic spin-off companies archetypically organize. The variations of which reflect a variety of characteristics of their institutional environment as well as the knowledge resources they assimilate in support of their goals and strategies.

Communities of practice

Some academic spin-off companies are identified by ambiguous or loosely-coupled social architecture in which its members work for the company but also appear to be working on many other (possibly unrelated) projects. *Communities of practice* (Wenger and Snyder, 2001; Lave and Wenger, 1991) are archetypical examples of organizational architecture whose characteristics reflect those of many academic spin-off companies. Wenger and Snyder (2001) describe a community of practice as a group of people informally bound together by shared expertise and a passion for a shared objective. They self organize for a variety of purposes, which would include the development of members' capabilities for a specific task, share insight and expertise, construct new meanings around the shared objective, and create knowledge. A community of practice is a social space that situates knowledge such that its members informally organize and "learn to construct shared understanding amidst confusing and conflicting data" (Raelin, 1997, p. 563).

Communities of practice are identified by self-selected membership, and they are sustained by passion, commitment, and identification with the group's expertise and objectives. Mutual trust among members is a particularly important aspect of sustaining such communities (Adler, 2001). Trust makes it easier to access and interpret information (McEvily, Perrone, and Zaheer, 2003). Intensified trust within communities enables increased knowledge sharing over time (Capaldo, 2007). A community of practice typically lasts as long as there is interest in maintaining the group.

Communities of practice exist within academic institutions as an alternative form of organization that enables members of a particular community to diversify their own knowledge. For example, Pallas (2001) argues that communities of practice within doctoral education will provide students with much needed epistemological diversity in order to avoid single-mindedness. Lattuca (2002) illustrates how people conduct academic work both within disciplines and across disciplines through participation in communities of practice.

In some cases, academic spin-off companies resemble communities of practice in that their organization is much looser than that of a company with an otherwise definitive boundary. An academic spin-off company is a social learning system of academic scientists. The company constructs its own network of learning with academic and industry colleagues, and it is connected to the learning system of the university from which it emerged. Partnerships and collaborations among scientists matter to the success of academic spin-off companies (Druilhe and Garnsey, 2004). Because of the lack of formal organization in some early stage enterprises, academic spin-off companies are characterized by more loosely coupled, flexible, and organic structures as well as blurred or ambiguous organizational boundaries (see Sine, Mitsuhashi, and Kirsch, 2006; Quinn and Cameron, 1983). As discussed in chapter one, the boundaries of some academic spin-off companies might not be clearly delineated from that of a particular university.

An academic spin-off company that takes the shape of a community of practice is likely to have a core group of scientists who routinely work together on projects specifically related to their venture. As members of a company, their role is likely to be formalized through contracts. In some cases, they might be paid as employees of the company, and in other cases the company might pay them as consultants. These core scientists might have appointments through both the company as well as through a university, hospital, or research institute. The spin-off company may or may not be a full time endeavour for them. If a core scientist maintains an appointment elsewhere, it is possible that they will include other scientists and researchers from their respective teams at the university, hospital, or research institute where they are employed. The other scientists and researchers will become part of the community of practice to the extent that their work contributes to the rhythm of company-specific projects, yet their connection to the company is through the core scientist and may be informal. Other scientists or researchers from the core group's extended network may also be tapped to work on specific aspects of a company project, but their involvement may be from a physical distance and may be limited to the achievement of specific deliverables. Because members of these academic spin-off companies maintain primary or secondary job appointments with other organizations, trust becomes an important aspect to their relationship with the company such that they adequately separate their work for the spin-off company from other work to the extent that confidential knowledge is not compromised.

Virtual companies

Similar to communities of practice, virtual companies are another form of organization by which trust is an organizing principle and whose designs are focused on the flow of knowledge. Unlike a community of practice in which members of the community will synchronously work together, members of a virtual company are likely to asynchronously work (sometimes at great physical distances from one another). Consider two types of companies at opposite ends of an organizational structure continuum. Chandler (1977) writes about the evolution and growth of the multi-unit business enterprise and defines the *modern business enterprise* as an organization characterized by "many distinct operating units, and it is managed by a hierarchy of salaried executives" (p. 1). Handy (1995) writes about the growth of virtual organizations and contemplates, "Organizationally, we have to wonder whether a company is, in the future, going to be anything more than a box of contracts that some companies now seem to be" (p. 41). Handy argues that trust is the organizing principle for virtual organizations. Similarly, Adler (2001) argues that trust is the organizing principle for communities. Chandler famously wrote about the growth of capital-intensive enterprises with their systems of mass production and divisions of labor and functions. Handy wrote about organizations driven by information and knowledge.

An alternative way of thinking about the continuum of organizational structure is to consider the flow of actions and the rhythm of work. In writing about organizational design, Bauer (2007) offers a way to think about project-based companies. "They succeed in creating a continuous flow of knowledge and people across projects, thereby lowering employee uncertainty and enhancing utilization of capacity. In short, these firms are integrated through rhythm rather than through structure" (p. 45). Bauer notes that the rhythm of work is becoming increasingly dispersed on a global level, which suggests more virtual forms of organization. A structure that is linked to a particular project may not permanently persist in a specific form, as project rhythms change. Social organizational structures evolve and dissolve in conjunction with the projects that they support. March (1995) refers to *disposable organizations* that emerge with an efficient means of addressing a particular challenge and subsequently disappearing when they are either no longer able to efficiently address the challenge or when the challenge changes or disappears.

Some academic spin-off companies pursue what Chesbrough and Teece (1996) describe as *autonomous innovations,* or innovations that are independent of existing technologies. In other words, they are not systemic and not part of an existing infrastructure. Instead, they are novel. They argue that virtual organizations are adept at producing these types of breakthroughs because the virtual structure speeds the requisite flow of new information and ideas among parties. This idea driven form of organization signifies a form of social architecture where knowledge is transferred for the purpose of achieving an innovative outcome. Biotechnology, in particular, witnesses a significant amount of virtual organizing. Although as Weisenfeld, Reeves, and Hunck-Mieswinkel (2001) note, some forms of virtual organization differ with respect to the commercialisation stage. They note that some networks organize around the R&D collaborations, while others organize around commercial projects that bring knowledge resources to market.

A virtual structure enables an academic spin-off company to have an extra-local reach beyond its original founding location. For an emergent venture, the ability to leverage a geographically global network of skills and insight provides the company with exponentially greater possibilities for assimilating knowledge resources and ultimately giving the company a potential competitive advantage. Many academic spin-off companies adopt extensive exploration strategies through major R&D efforts. Because R&D requires many non-routine activities, it is difficult to synchronize and situate such activities in a confined place. Malecki (2009) notes that R&D is an increasingly globalized phenomenon in which organizations manage cross-disciplinary knowledge flow across geographic distances. This is the result of the global decentralization of sources of knowledge as well as the desire to more efficiently access knowledge resources through collaboration. Organizations with a broad global network reach have access to more novel knowledge as a result of these weaker ties that extend from the structural holes within their networks (Whittington, Owen-Smith, and Powell, 2009). As such, an academic spin-off company's ability to navigate geographic space enables it to access more knowledge resources than its local environment provides, which ultimately connects it to more unique sources of knowledge.

A challenge for virtual organizing is the coordination of knowledge flow, which Amin and Roberts (2008) argue, "seems to work best when technological and human intermediaries are available to help cultivate a 'net' sociality building on purposefulness, social interaction, and affective commitment" (p. 364). In other words, much knowledge is available throughout network space. While technology can accelerate the rate of accessibility of this knowledge, human coordination remains a critical aspect of the assimilation and organization of this knowledge in meaningful ways.

A virtual academic spin-off company will resemble a distributed project rather than an established firm with any discernable operations. The company may exist in name only and be "physically" addressed at a venture capital firm office. A manager or a small group of managers who represent the investors of the company will coordinate a distributed network of scientists, researchers, and other experts who individually work on specific aspects of the "company's" project. Members of a virtual company have very little face-to-face interaction, but they communicate in many other ways including by phone, email, and web-conference. The nature of a virtual company is that its members work independently in loose confederation but, in doing so, enable members to have access to each other's knowledge and expertise. From the perspective of the company manager, a virtual company enables the company to gain access to the best expertise, regardless of location. In some cases, the requisite knowledge and expertise is not locally available, therefore necessitating a virtual form of organization. As with a community of practice, members of virtual companies have other jobs and need to maintain the trust of other members of the company to the extent that confidential knowledge is not compromised. To a much larger extent, large-scale multi-institutional projects such as the *Human Genome Project* (see Powell and Grodal, 2005) symbolize the nature of globally distributed and pluralist forms of organization that are increasingly common for achieving certain breakthrough innovations. Some virtual academic spin-off companies resemble the social architecture of the Human Genome Project at a much smaller scale.

Hierarchical companies

In addition to loosely-coupled, fluid, and organic organizational forms, some academic spin-off companies the adopt formal and bureaucratic architecture of hierarchical companies. Formality and bureaucracy in organizational architecture consists of such attributes as a clear division of labour and coordination among functions, sub-division of functions, specialization, and administration (Chandler, 1977; Blau, 1970). Some entrepreneurial companies emerge at the onset with this degree of formality, while these characteristics emerge in other companies over time as they evolve through life cycle stages and changing strategic needs (Quinn and Cameron, 1983). The appropriateness of formal and bureaucratic structure as opposed to informal and organic structure in entrepreneurial companies has been the subject of some scholarly debate (see Sine, Mitsuhashi, and Kirsch, 2006; Burns and Stalker, 1961). The goals and strategies play a role in determining the degree of formality, as organizing for the maximization of creativity often relies on the reduction of formal bureaucracy in order to facilitate an unrestricted flow of ideas (Freeman and Engel, 2007). To some extent, exploration strategies require less formal coordination of functions, while exploitation strategies require more formal coordination of functions.

Some academic spin-off companies resemble bureaucratic firms and adhere to more formal patterns of organization. In contrast to communities of practice and virtual companies, some academic spin-off companies will have a physical location where its members (scientists, researchers, and managers) work together under a division of labour and function. In colloquial terms, this is what one might expect to encounter when they visit a "traditional company."

Epistemological characteristics that affect organizational architecture

Innovation and the novel combinations of knowledge

The goals and strategies of academic spin-off companies will influence the extent to which they collaborate with other people and other organizations for the purposes of gaining access to knowledge resources. Some spin-off companies will establish many collaborative partnerships, while some companies may establish relatively few. The extent to which the company is externally connected to other people and organizations (colloquially, "how wide of a net does it cast") will influence the architecture of the company. Because academic spin-off companies emerge from academic research activities, some diversity within a company's network will be a function of the disciplinary diversity of the initial academic research.

Innovative outcomes represent unique and diverse combinations of ideas that are accessed through networks of people and organizations and subsequently combined in creative ways. As such, knowledge is an antecedent of innovation (Brökel and Binder, 2007). Scholars of creativity often equate the intellectual richness and diversity of knowledge resources with the likelihood of an innovative breakthrough. Gardner (1993) writes about the ways in which individual creativity evolves from the initial mastering of specific domains of knowledge to the desire to break free of the constraints of those domains by reorienting and reconfiguring them. Similarly, Simonton (1983) argues that individuals with advanced education in specific disciplines are susceptible to the constraints of disciplinary dogmatism, which can hinder their creativity because it limits the possibilities of novel ideas. Such ideas span multiple creative domains, including art, science, and business.

Breakthroughs in academic science often stem from scientists who, as Simonton (2004) notes, "are so open to novelty, complexity, and diversity in their already changeable environments, they necessarily have all sorts of ideas popping to mind unexpectedly. Their greater associative richness then expands and develops this unpredictable influx into equally unanticipated directions" (p. 177). Campbell (1960) illustrates such breakthroughs using evolutionary terminology in that variations in knowledge systems increase the likelihood that a scientific breakthrough is not simply left to chance.

> The sociology of knowledge makes an important contribution here: persons who have been uprooted from traditional cultures, or who have been thoroughly exposed to two or more cultures, seem to have the advantage in the range of hypotheses they are apt to consider, and through this means, in the frequency of creative innovation (Campbell, 1960, p. 391).

Similarly, Collins (1989) argues that knowledge is created based on the extent to which domains of knowledge within them evolve, and such evolution is dependent on the presence of intellectual conflict, the diversity of intellectual conflict at any given point in time, the accumulation of knowledge, and the synthesis of new ideas. In referring to such conflict in the context of intellectual history, Collins refers to the "divergent factions that make it go" (p. 112). Thus, advances in intellectual and scientific work are a function of intellectual diversity and the conflict among ideas that lead to new conceptualizations.

Academic spin-off companies are a category of social architecture that enables knowledge to be combined in unique ways because they represent a degree of separation from the sometimes-static and discipline-focused qualities of universities. They are epistemologically unencumbered and organized around a specific problem or opportunity, which means that they are free to seek any necessary intellectual resources. This is consistent with the concept of *requisite variety* (Weick, 1979; Ashby, 1956), which discusses the importance of building resource diversity into a system in order to match the naturally occurring disruptions and constraints to ongoing projects and the rhythm of work.

Innovation relies on collective knowledge because collective knowledge allows for novel and creative combinations of individual intelligence. To this point, Leonard and Sensiper (1998) write, "Creative ideas do not arise spontaneously from the air but are born out of conscious, semiconscious, and unconscious mental sorting, grouping, matching, and melding. Moreover, interpersonal interactions at the conscious level stimulate and enhance these activities; interplay among individuals appears essential to the innovation process" (p. 115). Some previous research has supported the notion of interdisciplinary collaboration and the emergence of new academic spin-off companies. Jong's (2006) study of the biochemistry departments at Stanford University, UC Berkeley, and UC San Francisco and the relationship to the San Francisco area biotech industry argues that UCSF gained an advantage in producing spin-off companies because of their scientists engaged in more cross-disciplinary collaborations and were more adept at advantageously integrating diverse sources of knowledge.

Organizing for innovation

Academic spin-off companies are organized as a means for converting a concept from academic research into a practical innovative outcome. In meeting these objectives, academic spin-off companies assimilate diverse intelligence and expertise from various sources. Crossan, Lane, and White (1999) describe a challenge that innovators (in this case, academic scientists with an idea) routinely face with respect to knowledge. They write, "True innovators have a problem akin to the child (trying to describe something for which it has no words to do so). They have a sensation – an insight into a possibility – but they have no literal language to describe it" (p. 527). The organization of an academic spin-off company enables scientists to assimilate a range of intelligence and expertise for the purposes of addressing a variety of practical problems.

An academic spin-off company, as an organized system of knowledge, is a function of intellectual and scientific diversity, and it is sustained, in part, by the continued presence of diverse knowledge resources. Gittelman and Kogut (2003) similarly describe small research-intensive firms. They describe the purpose of such firms as to "create a repository of knowledge; to act as an organizational mechanism to combine the capabilities of versatile scientists within and outside the boundaries of the firm; and to manage the selection of scientific ideas to produce valuable technical innovations" (p. 366).

Organizational systems benefit from diverse perspectives, skills, and experiences that can sometimes disrupt conventional wisdom and allow an organization to adapt to change through innovation (Cameron, Quinn, DeGraff, and Thakor, 2006; DeGraff and Lawrence, 2002). Organizations are comprised of individuals with unique tacit knowledge. Although the redundancy of similar tacit knowledge among individuals can provide an organizational system with valuable and sustained skill sets (Nonaka, von Krogh, and Voelpel, 2006; Nonaka and Takeuchi, 1995), non-redundant tacit knowledge is necessary for what Leonard and Sensiper (1998) describe as *creative abrasion*, which is a necessary aspect of organizational growth. They note:

> When a group of diverse individuals addresses a common challenge, each skilled person frames both the problem and its solution by applying mental schemata and patterns he or she understands best. The result is a cacophony of perspectives. In a well-managed development process, these varying perspectives foster *creative abrasion,* intellectual conflict between diverse viewpoints producing energy that is channelled into new ideas and products. (p. 118).

Networking for knowledge

Novel combinations of knowledge are not limited to the actions that occur within the formal boundaries of organizations, but they extend to interactions among organizations and their networks. Increasingly, scholars are recognizing that the locus of innovation and competitive advantage rests in cooperation among organizations (Campos and Pomeda, 2007; Barney, 1997). Several empirical studies (e.g. Inkpen, 2002; Powell, 1998; Gomes-Casseres, 1996; Powell, Koput, and Smith-Doerr, 1996) indicate this trend by showing that the quest for knowledge sharing and mutual learning brings organizations together. Collaboration is prevalent in high technology industries such as biotechnology and life sciences in which many academic spin-off companies operate (Hagedoorn and Lundan, 2001; Saviotti, 2001; Hagedoorn, 1993; Teece, 1992).

The extended networks of many academic spin-off companies include a variety of other organizations for the purposes of accessing knowledge-based resources, including universities, other start-up companies, large established firms, and consulting firms. Ogle (2007) argues that networks are an aspect of the extended mind and rich with knowledge. The challenge for using networks to achieve breakthrough innovation is a matter of finding knowledge that exists within network space and integrating it in novel ways.

> Networks are inherently value-creating spaces, so the trick for an artist, scientist, or entrepreneur bent on making a creative breakthrough is first and foremost to locate a suitable fertile space. Creative leaps are fundamentally a navigation problem (*don't waste time inventing it – it's out there somewhere; just find it and integrate it*) (Ogle, 2007, p. 239, author's italics).

Some studies of academic research commercialisation highlight the ways in which scientists benefit from their networks. Johansson, Jacob, and Hellström's (2005) study of academic spin-off companies noted that many of the founders maintained some position with the university (either part-time or full-time). They suggested that these scientists maintained such ties because of the long-term relationships and strong ties they had established within their departments. These relationships were built on trust. As time progressed, these relationships were a conduit for need for knowledge. Murray (2002) finds that science and industry networks often focus on individuals with dual roles in the academic research community as well as the industrial community.

Knowledge spill-over in these networks often occurs through joint research and publication efforts. Murray (2004) finds that the presence of academic scientists in spin-off companies is a source of tacit knowledge for the business. These individuals are also an important source of human capital for the business in that they build networks between their academic and industrial contacts.

Organizations with rich networks, as characterized by the presence of inroads to other networks, have access to more knowledge resources and are better adept at exploiting their own resources and innovating (Zaheer and Bell, 2005). Knowledge is created across network space when collaboration among non-redundant ties results in the increased flow of divergent ideas. As Hardy, Phillips, and Lawrence (2003) note, “From the perspective of the knowledge creation view, the more collaborative ties an organization has, and the greater the diversity of its partners, the more likely it will be successful at generating new knowledge” (p. 326).

The presence of a network comprised of non-redundant and weak ties provides academic spin-off companies and the people within them access to diverse insight. Insight diversity equips individuals with the tools for negotiating between creative and habitual actions (Ford, 1996) – doing so can spark new ideas. A weak tie network (Granovetter, 2005, 1973) can provide divergent viewpoints, propose alternative ideas, and stimulate “autonomous thinking” (Perry-Smith, 2008, p. 97). Perry-Smith and Shalley (2003) argue that weak ties provide a creative benefit up to a point because too much non-redundant insight can distract from the building of coherent ideas. Powell and Grodal (2005) argue that networks and innovation form a “virtuous cycle” (p. 67) in that collaboration facilitates innovation, and, consequently, innovation attracts further collaboration.

Academic spin-off companies have an inherent advantage as social entities that exist at the institutional boundary of higher education and the commercial-industrial sector. They occupy a position in network space that enables them to bridge structural holes across disciplinary and institutional networks of scientists and practitioners in an effort to impact the flow of non-redundant knowledge and expertise (Burt, 2004). Consequently, they are positioned to make creative leaps that yield new innovations because of their vantage point as integrators of knowledge. The goals and strategies of the company influence the extent to which a company will partner with other individuals or organizations for the purposes of assimilating relevant knowledge resources. Consequently, the extent of a spin-off company's connectedness will impact its organizational architecture.

Institutional characteristics that affect organizational structure

Academic spin-off companies exist at the institutional boundary between the higher education academic community and the commercial-industrial market environment. Consequently, the inter-institutional nature of spin-off companies impacts the nature of their organizational legitimacy and, ultimately, the ways in which they create and disseminate knowledge. Pfeffer (1976) argues that the management of an organization's institutional environment is critical for the development of the enterprise, especially as it relates to the legitimacy of the firm. Institutional factors pressure organizations to conform to “rules, myths, and structures” – some of which may only have symbolic value to the organization (Fennell and Alexander, 1987, p. 457) but are nevertheless necessary for the success of the organization and its legitimacy (see also DiMaggio and Powell, 1983).

The subsequent sections of this chapter will describe the ways in which academic spin-off companies negotiate the competing demands of academic and commercial legitimacy. The individual goals and strategies of each company impact the ways in which they seek legitimacy from the academic and commercial sectors, which coincides with the ways in which they organize for knowledge creation. Consequently, institutional factors impact the organizational architecture of academic spin-off companies.

Institutions as sources of legitimacy

Legitimacy matters to new business ventures and entrepreneurial start-up firms. To an entrepreneurial firm, legitimacy is an equally as important resource as capital, people, technology, and customers (Zimmerman and Zeitz, 2002). Likewise, entrepreneurial companies are burdened with a *liability of newness* (Hannan and Freeman, 1977; Stinchcombe, 1965) in which they have not yet amassed a requisite level of social, economic, and political resources. Therefore, because of their entrepreneurial nature, legitimacy matters to academic spin-off companies. They are innovative in their attempts to commercialize academic knowledge into practical applications. The exploitation of available knowledge is an aspect of these companies attempting to build legitimacy (March, 1995). As innovators, the legitimacy of academic spin-off companies matters to their stakeholders (Aldrich, 1999). It is critical that their investors (individuals, venture capital firms, institutional investors, etc.) perceive their legitimacy to the extent that the investors provide these firms with necessary funding. Similarly, Delmar and Shane (2004) note, “Because new ventures often do not appear as accountable and reliable as existing organizations, they need to create the external perception that they are legitimate to garner resources and survive competition with established firms” (p. 387). Rutherford and Buller (2007) argue that there is a point at which an entrepreneurial company has gained sufficient legitimacy for the purposes of survival and growth, and they refer to this as the *legitimacy threshold*. In this dissertation, legitimacy refers to “the extent to which people perceive that it (a new venture) adheres to accepted principles, rules, norms, standards, and ways of doing things” (Delmar and Shane, 2004, p. 388).

An academic spin-off company falls at the boundary of two institutions – the higher education academic community and the commercial-industrial sector. The academic institution is comprised of specific disciplines, schools of thought, etc. The commercial sector is comprised of specific industries and capital markets. Both institutions legitimize the activities of these companies and pressure them to conform to various norms, patterns, and processes of activities. Previous research (e.g. Colyvas and Powell, 2006) traces the legitimacy of academic research commercialization and the institutional blending of academic and commercial science. My research does not question the legitimacy of academic research commercialization but instead seeks to understand how academic spin-off companies – as organizational actors of academic research commercialization – balance the legitimising forces of the academic community and the commercial sector.

Johannison (1998) highlights a dilemma for scientists whose new business ventures were started in close relation to the academic community – "maintaining legitimacy in the academic community and the society at large while gaining legitimacy in the business community" (p. 298). Kleinman and Vallas (2001) note that academic and industrial work follows a process of *asymmetrical convergence* in which "codes and practices of industry" affect academic work, and "academic norms" affect work practices in high-technology industries (p. 451). They argue that such asymmetry results in blurred boundaries between academic and industrial work, which results in newly institutionalized patterns of practices. Such asymmetry could also result in conflicts of legitimacy in which one form of institutional legitimacy could be gained at the expense of another form of institutional legitimacy (Gumport, 2000). Institutions limit the flexibility of human actions (Berger and Luckmann, 1966). The importance of both academic and commercial institutional norms likewise heightens this inflexibility for academic spin-off companies.

Another possibility is that institutional asymmetry results in patterns of compromise and negotiation. Smith-Doerr (2005) argues that multiple forms of legitimacy and institutional norms are especially likely in enterprises (biotechnology companies in her study) that adhere to a more loosely coupled and networked forms of organization. This lends some especially relevant insight into my study of academic spin-off companies, which are more likely to follow this form of organization. She writes, “Ongoing ties with labs in universities and with other biotech firms, as well as close connections to venture capitalists and pharmaceutical corporations provide the mechanism for intermingled narratives” (p. 293).

Academic legitimacy

An academic spin-off company’s affiliation with the university from which it emerged as well as its affiliation with the academic and scientific communities can signal the legitimacy of the enterprise. Some recent research suggests this – universities strengthen the external prestige and legitimacy of the spin-off companies that emerged from them (Powers and McDougall, 2005; Feldman, Feller, Bercovitz, and Burton, 2002). Likewise, legitimacy can flow in the opposite direction. Geiger and Sá (2008) note that academic spin-off companies strengthen the external prestige and legitimacy of the respective universities from which they emerged.

Mutual legitimacy of academic and commercial activities can occur when both sides increase their understanding of the other. Mosey, Lockett, and Westhead’s (2006) study offers and interesting example of how mutual legitimacy can work in practice. Their study of biomedical departments at a group of universities in the United Kingdom considered the impact that fellowship programs had on serving as a bridge between academic and business networks. They found that fellowship programs lead to positive attitudes of academic scientists toward commercialisation and increase the likelihood that scientists will view such work as a legitimate academic activity. Likewise, the program increases the entrepreneurial literacy of academic scientists, which strengthens their relations and improves their credibility with the commercial sector.

Because the knowledge base of academic spin-off companies stems from academic science and academic research, these firms rely on the credibility of the academic community and the ways in which the community bestows such credibility on scientific work. Tornikoski and Newbert (2007) suggest that the legitimacy of a new firm rests, in part, in the collective abilities of the founding team. These abilities include educational and professional experiences. Therefore, a new business that is based on academic science would gain some of its legitimacy from the credibility of the knowledge base of the founding scientific team (see also Brennan, Wall, and McGowan, 2005). Similarly, Murray's (2004) study of academic inventors in entrepreneurial firms noted that scientists who affiliated with a company "signalled" the quality of the science conducted at the company.

Universities bestow legitimacy on knowledge and on those who produce it (Gumport and Snydman, 2002). Universities organize through disciplines and consequently generate social capital, which acts to legitimize academic knowledge (Arnoldi, 2007). The politics and ceremony of academic conferences and the peer review process of publication reinforces these professional standards of credible knowledge, which can subsequently legitimize the knowledge base of academic spin-off companies by virtue of the firm scientists' continued involvement in the academic community (see Collins, 1998; DiMaggio and Powell, 1983). The knowledge base of the university and the overall institutional credibility of academic science serves as a standard against which the knowledge of an academic spin-off company can be judged. Credible knowledge that is associated with a university research team or a scientific field can signal the legitimacy of an academic spin-off company. In the absence of otherwise quantifiable and rational measures of the value of an academic enterprise (for example, its profitability), knowledge resources represent future innovations and can signal the legitimacy of the company (see Feldman and March, 1981; Meyer and Rowan, 1977).

Interestingly, an academic spin-off company's academic legitimacy is not necessarily limited to that which it gains from its "home" university. A spin-off company that seeks the legitimacy of the academic community may seek it from its local home university, but it may also seek the support of academic experts in a particular field of study in other parts of the world. Golob's (2006) study of academic start-up companies in the New York City area demonstrates that geography and university affiliation are not the only factors that affect a company's decision to locate near a university. Key relationships and collaborators also drive the location of these companies, which may preclude them from establishing a presence near their originating university. Thus, a region with a university may produce a cluster of spin-off companies, but the boundaries of that cluster, as defined by the web of firm stakeholders, may extend beyond the boundaries of the university's local geography (see Porter, 1998).

In any given network of innovation, knowledge is not exclusively fixed to a particular location, and people can have relational or social proximity in order to access knowledge from each other without having physical proximity (Amin and Cohendet, 2005). Thus, geographic proximity between a university and an academic spin-off company impacts both its strategies for assimilating knowledge resources as well as its potential sources of academic legitimacy. The global characteristics of the higher education academic community indicate a level of convergence around institutional norms of determining credible knowledge (Hotz-Hart, 2000). Therefore, an academic spin-off company can access academic knowledge resources from around the world, and those resources retain a global level of credibility and legitimacy.

Commercial legitimacy

The challenge for any entrepreneurial venture is to gain financial resources to support and sustain the operations of the venture. In the case of an academic spin-off company, those resources are necessary to support a variety of critical business functions including R&D activity, clinical trials, the manufacturing of products, the hiring of talented staff, and the eventual scaling of the business. From the perspective of potential investors who face risk if they choose to invest, an academic spin-off company must be perceived as a legitimate enterprise in order for the investor to ascertain the level of risk (Aldrich and Fiol, 1994). Venture capital (VC) firms typically serve as a resource for investment capital in academic spin-off companies and provide the necessary financing to support such critical business functions. For an academic spin-off company, it is necessary to gain legitimacy from the perspective of these financial stakeholders in order attract investment in the enterprise.

VC firms provide academic spin-off companies with critical financial resources by investing and taking an equity stake in these companies (Wright, Lockett, Clarysse, and

Binks, 2006). Like other non-academic start-up companies, the relationship between the company and the VC firm is relationship driven. In a study by Knockaert, Wright, Clarysse, and Lockett (2009), the authors found that VC firms have a positive attitude toward investing in academic spin-off companies if the firm maintains relationships to individual academic scientists and if the investors have institutional familiarity to academic science and higher education. The authors note that these VC investors have human capital characteristics that are similar to those possessed by academic scientists. Shane and Stuart's (2002) study of MIT spin-off companies notes that academic scientists benefited from having ties to members of the VC and business communities such that it increase the likelihood of a company's long-term success.

University technology transfer offices play an important role in brokering relationships among VC firms and the academic spin-off companies. The process of raising venture capital for early stage enterprises is very relationship driven, and VC firms tend to invest within their geographically localized networks when a potential early stage venture has not yet proven itself (Powell, Koput, Bowie, and Smith-Doerr, 2002). Technology transfer offices play a critical sensegiving role by packaging and selling potential investments in academic ventures to VC firms and, consequently, promoting the commercial legitimacy and investment viability of these companies. Academic scientists look to technology transfer offices for guidance with critical business skills and cultivating relationships with VC professionals (Jain, George, and Maltarich, 2009). However, some university technology transfer offices lack sufficient relationships with VC firms, which can make it difficult for otherwise commercially inexperienced academic scientists to network with and receive necessary funding from VC firms (Wright, Lockett, Clarysse, and Binks, 2006).

Universities also play an interesting role in supporting commercial legitimacy. Individual university missions and department level policies that promote entrepreneurship and academic research commercialization offer some level of assurance to academic scientists at those universities that commercialization is an academically legitimate activity and worthy of their time. Universities vary in their promotion of academic research commercialization. A university's own founding mission, history, past interactions with industry, and institutional context can affect the way it supports entrepreneurship and economic development in a given geographic region (Feldman and Desrochers, 2003). Kenney and Goe (2004) studied entrepreneurship activities (which included the founding of spin-off companies) in the electrical engineering departments at Stanford University and UC Berkeley and found that Stanford's department was more supportive of faculty entrepreneurial activity, thus signifying it as a legitimate activity.

Symbols, sensegiving, and the negotiation of institutions

Some scholarship has explored a variety of mechanisms that describe the ways in which legitimacy is accumulated. Symbols and symbolic action are a means of signalling legitimacy and enable people to construct mental models of an otherwise unknown or ambiguous new enterprise (Zott and Huy, 2007). Attendance at an academic conference is an example of a symbolic action that can signal legitimacy in a new enterprise. "Actions as well as objects can display both intrinsic and symbolic dimensions. For example, an entrepreneur speaking at prestigious conferences to disseminate knowledge (intrinsic dimension) is also conveying the message that established people recognize and value his or her expertise (symbolic meaning)" (Zott and Huy, 2007, p. 72). Similarly, Davenport and Prusak's (2003) work emphasizes the importance of publications and conferences as legitimizing symbols for knowledge work that is marketed through "idea markets" – or channels that pair consumers of intellectual property with the providers of tacit knowledge. Such symbols and actions illustrate ways in which people involved in establishing and growing an academic spin-off company navigate academic institutional space. They are also examples of the everyday activities in which these scientists engage that reproduce the institutional landscape of the academic community (see Powell and Colyvas, 2008).

Other symbols and actions illustrate the ways in which commercial institutional space is navigated. Higgins and Gulati (2003) note that start-up firms use "externally validated symbols of legitimacy" as a means of signalling the firm's present and potential future viability in an otherwise ambiguous economic marketplace. Such symbols include the firm's number of patents (i.e. its base of intellectual property), the firm's affiliations with prominent organizations, and the firm's experience base. Their study of young biotechnology firms demonstrates that higher levels of legitimacy – as operationalized by affiliations with other organizations – increases a firm's ability to attract a high-prestige investment bank in the underwriting of the firm's initial public offering of stock.

In an entrepreneurial environment, the burden of developing a vision for a new company and signalling that vision falls into the hands of the entrepreneur. Academic entrepreneurs are no different. For an academic spin-off company, the legitimacy of company's knowledge base will be a component of the communication of that vision to stakeholders. Scholars offer a variety of ways in which such communication occurs. For some, it is framed as a process of *sensemaking* and *sensegiving* (Holt and Macpherson, 2010; Maitlis and Lawrence, 2007; Hill and Levenhagen, 1995). In other instances, the process is framed as *narrative construction* (Golant and Sillince, 2006; Barry and Elmes, 1997) or *storytelling* (Lounsbury and Glynn, 2001). There is also the argument that it is an *advocacy* process (Golob, 2006). An entrepreneurial scientist who launches an academic spin-off company will have the responsibility to frame a credible and legitimate mental model of their business and their science and subsequently frame that mental model in such a way that they draw support from stakeholders.

If the entrepreneurial scientist constructs a narrative of his or her business and the knowledge from which it stems then "the power and influence of key actors and networks is such as to support and legitimize the narrative, and to contribute to its being retold in different settings" (Morrell, 2008, p. 616). Because the university technology transfer office shares an interest in the success of academic start-up firm with the individual scientists (Colyvas, et al., 2002), the technology transfer office plays a role in the scientist's narrative and helps the scientist frame a credible and legitimate mental model of the nature of the business and its scientific knowledge base (Jain and George, 2007).

The negotiation of multi-institutional norms of legitimacy is a challenge faced by academic spin-off companies. Academic spin-off companies exist at the institutional boundary between the norms and practices of academic and commercial institutions, which inherently suggests that those involved in such organizations will face a variety of situations in which their actions will strike a balance or a compromise between sets of institutional factors. Just as academic spin-off companies strike a balance between the short-term objectives of exploiting their knowledge resources at hand and the long-term objectives of creating new knowledge, companies must also strike a balance between the institutional factors and legitimacy factors that most appropriately support the exploration and exploitation strategies. In a case study of a biotech company, Weisenfeld, Reeves, and Hunck-Meiswinkel (2001) note a critical trade-off faced by companies that are subject to the norms and practices of both academic science and the building of a commercial venture. The authors note:

> The timing of innovations is crucial for the competitive position in the market. Often pre-competitive information on research results can be exchanged among scientists through informal know-how trading. But, in the competitive stage, specific know-how might be confidential. Thus, the members of virtual companies face the special problem of finding the balance between keeping confidential information and giving necessary information (p. 96).

In writing about the development of science as a business, Pisano (2010) similarly reflects on the inter-institutional negotiation of science-based businesses:

> Both science and business are intensely competitive worlds, but their markets and currency are distinct. In science, score is kept by peer review and grant givers, and measured ultimately by reputation; in business, score is kept by capital markets and measured by profitability. Publication is synonymous with science, secrecy synonymous with business (p. 470).

Companies whose knowledge base is rooted in academic science face the conflict of an exploratory strategy that necessitates the sharing of scientific findings and the networking with colleagues but also an exploitative strategy that necessitates the protection of scientific findings as intellectual property. In short, striking a balance between competing sources of legitimacy is a consideration determined by the goals and strategies of the company.

Organizationally, this balancing act and subsequent compromises will coincide with the transparency of the company. An academic spin-off company that requires a strgically credible scientific narrative will structure itself such that it is openly transparent and collaborative with members of the academic community. The degree of transparency will coincide with the strategic benefit it gains from achieving academic legitimacy.

Creating knowledge

Organizational knowledge

Various streams of organizational theory literature have articulated a knowledge-based perspective of organizations as social architecture of embedded knowledge. Because of the uncertainties of the future and the ambiguities of ongoing projects, organizations are, inherently, problem-solving, information-seeking, and sensemaking entities (Weick, 1995; Stinchcombe, 1990; Cyert and March, 1963). Organizations assimilate the specialized skills, deep smarts, and intelligence of people (Leonard and Swap, 2004; Glynn, 1996; Grant, 1996) and manifest such knowledge as processes and routines (Zollo and Winter, 2002; Nelson and Winter, 1982), activity systems (Spender, 1996), memory practices (Bowker, 2005), interpretations, and constructions of meaning (Daft and Weick, 1984). Organizations are social systems that fit into ecologies of learning and shape the ways in which knowledge is constructed and meaning is developed (Kolb and Kolb, 2005).

Organized knowledge is rooted in our individual cognitive limits. Individuals simply cannot know everything. Instead, we create structures within society through which knowledge is distributed and through which it can be cultivated (Hayek, 1989, 1945). Likewise, Berger and Luckmann (1966) refer to the "social distribution of knowledge" (p. 43) as the inability and reluctance to possess knowledge of everything, which leads to the social construction of systems of expertise that organizes and distributes knowledge as needed. Organizations distribute knowledge in a systemized manner (Tsoukas, 1996), but organizations are still limited by the bounded nature of the intelligence of the people within them (March and Simon, 1956). These limits can be extended when organizational knowledge is conceived through broader social structures such as communities and networks (Ogle, 2007; Brown and Duguid, 2001).

Academic spin-off companies adhere to these principles of organizational knowledge and exhibit many complex social properties associated with the assimilation of knowledge and the amplification of collective intelligence. The academic scientists who initially organize do so to address and solve problems. As necessary, they assimilate others to help them do so. Included in this is the involvement of technology transfer office professionals, other commercialization experts, investors, and managers who bring specialized expertise about how to raise money, how to structure the problem-solving challenge as a commercial enterprise, as well as specialist scientific skills. Academic spin-off companies can function as learning environments in which senior scientists and students learn from one another and contribute specialized expertise to the problem at hand. Academic spin-off companies sometimes establish relationships with other organizations (for example other companies, universities, or research institutes) for the purposes of engaging their specialized expertise.

This organizational knowledge perspective of academic spin-off companies reveals the complexities of academic research commercialization as a social process that extends beyond the transaction-based view of technology transfer and intellectual property licensing, which tends to dominate the study of this phenomenon. The study of academic spin-off companies represents an alternative domain in the broader study of university technology transfer (Powers and McDougall, 2005). Geiger and Sá (2008) note that spin-off companies are an effective means of academic research commercialization when the tacit knowledge of individual scientists is required for successful development over a longer period of time. In a review of literature on the characteristics of companies and their ability to utilize externally-generated scientific knowledge from universities, Agrawal (2001) notes that the issue of tacit knowledge transfer is at the heart of scholarship on academic research commercialization.

> While there may be gains possible from increased efficiencies in transactions associated with codified knowledge, the focus on topics associated with tacit knowledge transfer suggests that this is the central issue, and it generates the majority of the variance in terms of firms' relative abilities to utilize university inventions effectively. Thus, research that contributes to our deeper understanding of tacit knowledge and how it is transferred would offer a worthy contribution to work in this area. (Agrawal, 2001, p. 291).

In summary, this dissertation addresses the complexities of the subject of knowledge. Knowledge resides in the minds of individuals, but the collective aspects of social systems elucidate what people know and further embed collective intelligence. Knowledge in its tacit form is what resides in our minds or expressed inn routines or actions. Knowledge in its explicit form is what resembles codified intelligence – such as anything written. Furthermore, the distinction of tacit knowledge represents an area of interest in the field of academic research commercialization.

Knowledge creation

Academic spin-off companies are organizations that create and transfer knowledge. Through this role, they are members of the *knowledge economy* (Powell and Snellman, 2004; Drucker, 1993), which can be defined as "production and services based on knowledge-intensive activities that contribute to an accelerated pace of technical and scientific advance, as well as rapid obsolescence" (Powell and Snellman, 2004, p. 201). Through the research and development (R&D) in which they are involved, they create knowledge. By disseminating research findings through academic channels or by marketing their knowledge within the commercial sector, they transfer knowledge. Existing streams of literature reveal the mechanisms for knowledge creation.

Knowledge creation broadly describes the iterative cycle of questioning and answering. In doing so, we update and refine what we know about the world through iterations of solutions, critiques, and modified solutions (Lee and Cole, 2003). Nonaka, von Krogh, and Voelpel (2006) differentiate between individual and organizational levels of knowledge creation. At the individual level, they posit that "knowledge creation can be understood as a continuous process through which one overcomes the individual boundaries and constraints imposed by information and past learning by acquiring a new context, a new view of the world and new knowledge" (p. 1182). They argue that organizational knowledge creation is an equally iterative process of "making available and amplifying knowledge created by individuals as well as crystallizing and connecting it to an organization's knowledge system" (p. 1179).

In considering the ways in which academic spin-off companies create knowledge, one must consider the role of scientific research as a means of knowledge creation. Because academic spin-off companies are by nature, academic, the ways in which they create knowledge adhere to principles of science and scientific research. Academic spin-off companies create knowledge by addressing practical problems through scientific means. Popper's (1972) theory of the growth of knowledge is the theory of solving problems by proposing, discussing, evaluating, and criticising theories. The growth of knowledge stems from the movement among problems and the effort to solve and explain them. "We learn about our environment not through being instructed by it, but through being challenged by it" (Popper, 1972, p. 266). In writing about ways to increase the social relevancy of universities in the 21st century, Greenwood and Levin (2001) similarly raise the issue of conducting academic research in a way that addresses practical problems through iterative knowledge creation processes – or action research. They write, "Through active experimentation in a holistic situation aimed at solving problems relevant to the collaborators, knowledge is created through emergent, workable solutions" (p. 435).

Through the technologies they create or the services they offer, academic spin-off companies have created knowledge because the scientific skills they have assimilated and deployed have, organizationally, turned "disorder into order" and achieved some degree of "closure" in the form of a solution (Patriotta, 2003, p. 11). They "act their way into understanding" by learning what works, what doesn't work, making sense, challenging assumptions, and updating beliefs and conceptions (Weick, 2004b, p. 76). In other words, evidence of knowledge creation is expressed in thoughts of understanding, intelligent actions, expressions of understanding, and artifacts that embody intelligence and understanding.

Academic institutions play a role in facilitating knowledge creation by encouraging the ongoing re-evaluation of theories and beliefs. Shaw (2005) notes, "A university's most valuable contribution is not the mere knowledge it acquires or the information it imparts. More important is the training it provides in the disciplined use and bold reinvention of models" (p. 64). Kuhn (1970) writes about scientific revolutions and argues that knowledge paradigms represent unprecedented scientific achievements but that they are sufficiently open-ended such that they enable the possibility of related work that updates and refines them and addresses new problems. The perspective of academic science holds that knowledge is created through the tension that occurs within the debates between old and new assumptions. "All education depends on two equally important tendencies – one restraining, the other encouraging, the criticism of models. If skepticism has no play, the established models of a discipline like history or physics will cease to be tested or defined, and learning will cease to advance in these areas" (Shaw, 2005, p. 167).

Another relevant stream of research about knowledge creation that relates to the study of academic spin-off companies is rooted in organizational theory and considers the actions of individuals in collective settings. Patriotta (2003) offers a review of several sub-streams in organizational research that addresses the issue of organizational knowledge and argues that, at its root, knowledge is created when organizations appropriate order from disorder.

Nonaka and Takeuchi (1995) propose what is now a seminal theory of organizational knowledge creation. In their study of knowledge creation at Japanese companies, they find that knowledge is created through the interaction between tacit and explicit knowledge. According to their theory, knowledge is created by individuals, and organizations "amplify the knowledge created by individuals and crystallize it as a part of the knowledge network of the organization. This process takes place within an expanding "community of interaction," which crosses intra- and inter-organizational levels and boundaries" (Nonaka and Takeuchi, 1995, p. 59). This is the pattern of knowledge creation in academic spin-off companies. Individual scientists create knowledge. The organizational structures of both the universities and the academic spin-off companies, thus, "amplify" this knowledge and crystallize it into networks that span the boundaries of universities and the economic marketplace. These mechanisms also relate to those proposed by Glynn (1996) in that individual knowledge, or "intelligence," is aggregated, codified as organizational knowledge, and embedded in organizational structures and actions.

Multi-institutional factors and knowledge creation

An important aspect of knowledge creation is a negotiation of the institutional landscape in which such work is conducted. The inter-institutional qualities of academic spin-off companies and the plural legitimacy that each company seeks from the academic and commercial sectors have interesting implications for knowledge creation. Because of the practical nature of the problems an academic spin-off company is organized to address, they are motivated by the efficacy of what they produce rather than by the sole search for an absolute scientific truth. This does not mean that a spin-off company is unconcerned with the production of valid knowledge. Instead, *is it valid* becomes just as important a criteria as *does it work* and *does it satisfy our stakeholders?* These three criteria lie at the heart of the inter-institutional nature of academic spin-off companies.

Consequently, these companies adhere to a constructivist view of knowledge. Knorr-Cetina (1981) notes, "The "products of science are contextually specific constructions, which bear the mark of the situational contingency and interest structure of the process by which they are generated, and which cannot be adequately understood without an analysis of their construction" (p. 5). An academic spin-off company produces knowledge that is contextually specific to the academic disciplines and paradigms in which it is situated and which is contextually specific to the market-based norms and expectations of investors and customers. Academic scientists, business managers, investors, and customers comprise the multi-institutional stakeholder base that constructs a context in which academic spin-off companies create knowledge. An academic scientist who works under the auspices of a capitalist academic spin-off company adheres to the notion of scientific credibility and the monopoly of certain knowledge that they can exploit in the marketplace (see Knorr-Cetina, 1981; Latour and Woolgar, 1979).

Legitimacy matters to academic spin-off companies. Investors must consider them to be legitimate and viable commercial enterprises that are worthy of continued investment. Members of the academic-scientific community must consider them to be legitimate scientific communities in that the work that they do must meet appropriate standards of validity. Therefore, the knowledge that academic spin-off companies create must be constructed with appropriate attention directed to the overall legitimacy of the organization, which amounts to an important strategic decision. Knorr-Cetina (1981) writes, "One finds that validations are made with an eye toward the genesis of the results being validated. Whether a proposed knowledge claim is judged plausible or implausible, interesting, unbelievable or nonsensical, may depend on *who* proposed the result, *where* the work was done, and *how* it was accomplished" (p. 7, author's italics). For example, the results of a clinical trial for a new drug may yield academically valid findings based on the credibility of the employed research design and protocols, but the findings might not satisfy an investor's threshold of efficacy in order to warrant continued investment in future trials, therefore potentially rendering the company an economically illegitimate and unviable investment opportunity.

Some scholars of the sociology of science are skeptical of the purity and objectivity of scientific activity. They instead argue that individual scientists are cognizant of the "game" played by other members of the scientific community. Bourdieu (2004) writes:

> A good scientist is someone who has a sense of the scientific game, who can anticipate criticism, and adapt in advance to the criteria defining acceptable

> arguments, thus advancing the process of recognition and legitimation; who stops experimenting when he thinks that the experimentation conforms to the socially defined norms of his science and when he feels sufficiently assured to confront his peers (p. 83).

Members of an academic spin-off company who create knowledge will do so with these concerns in mind. To a skeptic, a scientist with an academic spin-off company who is deliberately careful about how much of its knowledge base is publicly disseminated is merely "gaming the system" of academic science in order to benefit their company. An optimist might alternatively view such "gaming" as a way to sustain the interest of its suitors – the investors who keep the money flowing into the company so that it can continue its R&D in order to produce an efficacious output that ultimately becomes a public good.

Chapter summary and conceptual framework

This literature review has considered a cross section of several diverse areas of scholarship that intersect at the subject of academic spin-off companies and knowledge creation. Various practical goals motivate the founding of academic spin-off companies, as academic scientists recognize the practical benefits that can be realized from their academic research. Skepticism toward existing knowledge or open-ended scientific findings coupled with the desire to solve real-world problems manifest as goals, which lead to the determination of short-term and long-term strategies for an emergent academic spin-off company that is organized to work toward the achievement of these goals.

Academic spin-off companies organize under various forms of social architecture, which reflects the nature of the work in which they are engaged and the knowledge they seek to create. The social architecture of certain academic spin-off companies can be fluid, loosely coupled, and organized around specific projects. Such companies can incorporate frequent interaction among geographically proximate scientists, while other companies can manage virtual collaboration among geographically dispersed parties. Other companies can be hierarchical, with clearly defined roles, responsibilities, and areas of expertise.

Epistemological and institutional factors can affect the social organizational architecture of academic spin-off companies. Some companies may widely collaborate with other individuals or organizations in order to assimilate diverse expertise from outside their organizations, while other companies may be more reluctant to collaborate and may internally assimilate the requisite knowledge resources. Thus, epistemological factors affect the connectedness of academic spin-off companies. As organizations whose legitimacy stems from adherence to both academic and commercial norms, some academic spin-off companies may reveal much of their knowledge base to external parties and strongly adhere to the norms of academic research dissemination, while other companies may adhere to the norms of the commercial sector, disseminate few knowledge resources while protecting them as forms of intellectual property. Thus, institutional factors affect the transparency of academic spin-off companies.

When the goals and strategies of academic spin-off companies are directed toward addressing practical problems, such efforts create knowledge because they reveal new insights about the world, and they update existing knowledge-at-hand. Some knowledge is codified and disseminated through conference presentations and academic publications. Some knowledge is tacit and manifests in services offered and the routines enacted by academic spin-off companies in the delivery of services. Routines that embody the personal interactions among scientists capture knowledge, which is subsequently embedded into the social architecture and knowledge base of an academic spin-off company. The creation of knowledge by an academic spin-off company is more complex than a sequence of inputs and outputs. Academic spin-off companies form a category of social organizational architecture whose people sense the challenges of the world in which they live, understand various areas of academic thought that make meaning of the world, assimilate these thoughts as knowledge-based resources, and recombine them to update existing meanings and derive new ones. These efforts are aimed at using intellectual resources to make the world an incrementally better place by developing academic insight into practical innovations.

Figure 2.1 on the following page summarizes this literature review and these summary points as a conceptual framework that will guide the empirical portion of this study.

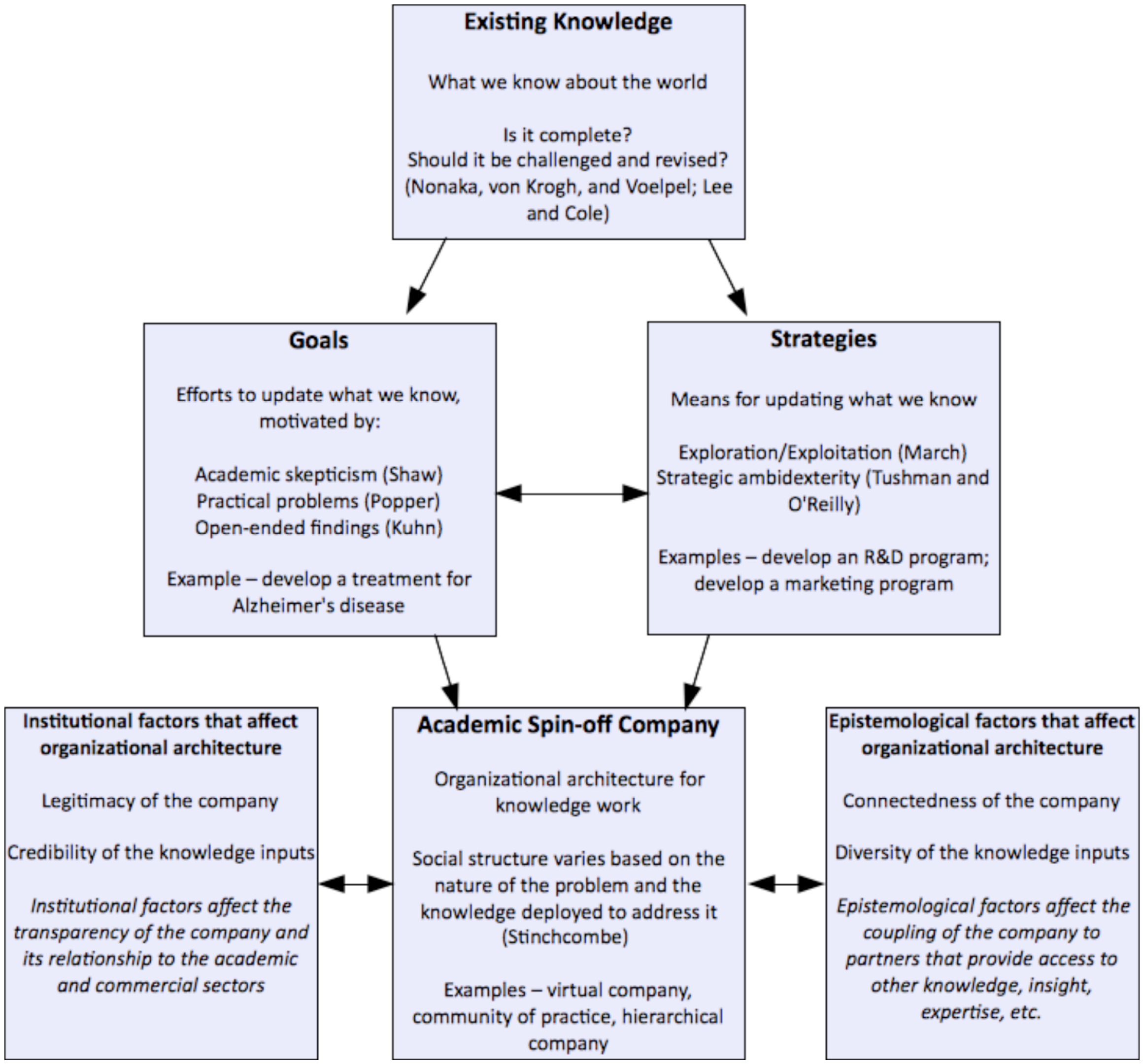

Figure 2.1 – Conceptual framework

Chapter 3 – Research Design

Research site, sample, and methodology

Overview

This chapter describes the qualitative research methodology of this dissertation. There are six cases in this dissertation, and each is an organizational level of analysis. The analysis of themes across each case will address the research questions. Each case is an academic spin-off company associated with the University of the Southern Hemisphere (pseudonym) in Australia. I conducted the study from the company's point of view, providing an "outside in" frame of reference regarding the company's relationship with the academic community. I visited Australia in October 2007 in order to conduct some preliminary investigation into this research site and topic and to ascertain the feasibility of the study.

Data consist of two primary categories – interviews and company documents. There are a total of 18 interview respondents spread among the six companies. Respondents consist of a mix of company scientists, company officials, and venture capital professionals. I conducted 15 interviews at respondents' worksites in Australia during a four-week time period during November-December 2008. I conducted three additional interviews by phone during July-August 2009 with individuals I was unable to meet in person during my fieldwork. Additionally, I analyzed a total of 287 company documents across all six companies for the purpose of building richness and deeper context in the development of each case.

This dissertation adheres to the tenets of inductive theory-building rather than deductive theory-testing. The scope of this project lends itself to mid-level theorizing as it explores academic spin-off companies through the intersection of several theories and concepts. Through a combination of these various theories and concepts as well as the richness of qualitative data, this dissertation will conclude with propositions and directions for future research.

Research site

My sample will consist of spin-off companies that were established in some connection with the University of the Southern Hemisphere in Australia – a university and surrounding regional innovation system that makes an appropriate site for answering the proposed research questions. The University of the Southern Hemisphere is a large institution with over 40,000 students and a sizable research budget.

Australia is the leading center for biotechnology and life sciences research in the Asia-Pacific region (Gilding, 2008; Herpin, Karuso, and Foley, 2005), although anecdotal evidence suggests that Australia faces competitive pressures from Singapore in retaining this title. The presence of biotechnology and life sciences is a strong barometer for academic entrepreneurship and university-industry knowledge transfer. Research in these disciplines is often regarded as sitting at the leading edge of technology transfer and academic research commercialization activities, and these disciplines are some of the most influential academic disciplines to industry (Mowery, 2007; Shane, 2005; Powell and Owen-Smith, 1998). Regions that show promise in biotech are likely to also show promise in other entrepreneurial industries. Thus the selection of a region that is relatively strong in biotech and life sciences is likely to yield multiple opportunities for research on academic entrepreneurship. Ten of twenty new Australian biotech firms created in 2004-05 were spun off from universities, and in 2004, two-thirds of Australian biotech companies were based on university research either in whole or in part (Marceau, 2007).

Much of Australia's economic growth is occurring in small to medium-sized enterprises, or firms (SMEs) (Group of Eight, 2005). SMEs yield the most innovative outcomes when they participate in knowledge-sharing cooperative networks (Mohannak, 2007). SMEs are increasingly interested in acquiring capabilities and long-term relationships more so than simply acquiring raw technologies. Academic spin-off companies, like other entrepreneurial ventures, are usually SMEs in the early phases of their existence. There are a total of 30 such companies that have founding ties with the University of the Southern Hemisphere.

Australia is an interesting place in which to conduct this research. In the context of today's rapidly changing and globalising economy, geographic place – and the high quality human and intellectual capital embedded within such places – matters in the modern creative economy (Florida, 2009; Lee, Florida, and Acs, 2004). Florida argues that mega-regions in various worldwide locales house a variety of respective knowledge hubs that connect to other hubs on a global scale. Australia's geographic isolation physically constrains the size of its domestic hubs, but its isolation does not restrict the connectedness of its hubs to the rest of the world. As discussed in chapter two of this dissertation, the navigation of geographic space is an important aspect of the study of academic spin-off companies, and Australia's location provides an interesting geographic starting point.

Australia is an interesting example of recent trends in the global scope of knowledge development. Universities and the people associated with them form local knowledge hubs, as is the case with the University of the Southern Hemisphere and the clustering of companies near its campus. Yet this local hub connects to other networks in other corners of the world. The academic community is one of the important means through which this connectedness is possible. Scientists attend conferences all over the world, form connections with one another, and collaborate across these long distances on a variety of projects. Thus, a dissertation that explores the access, creation, and transfer of knowledge from the perspective of cases that originate in an isolated region of the world can offer rich conclusions about the global aspects of knowledge flow.

The Australian innovation system is gaining international recognition. Florida (2004) writes that Australia is fast becoming a global center for creativity and innovation, and it ranks ahead of the United States on metrics that define a national profile of creativity and innovation. He attributes this trend in part to an investment in higher education and an ability to attract creative foreign talent (this foreign talent is even being attracted away from the U.S.).

Research sample

I selected the University of the Southern Hemisphere as a starting point for the selection of university-based spin-off companies because of the presence of many life sciences companies in the surrounding region. I subsequently used the university technology transfer office to narrow my selection. Nicolaou and Birley (2003) used a similar collaborative approach with the technology transfer office at the Imperial College of London in the identification of their sample for their study of academic inventors and start-up companies. Likewise, Shane and Stuart (2002) received the names and related data of all MIT-based start-up firms from the MIT technology transfer office.

University Enterprises Pty Ltd. (pseudonym) is the university's technology transfer office. It is a private company that is wholly owned by the University of the Southern Hemisphere. University Enterprises was established in 2003. University Enterprises was established as part of the university's effort to be more proactive in the commercialization of research. Prior to the establishment of University Enterprises, research commercialization was mostly reactive in that a researcher would approach the university's research office for assistance in the commercialization process. The establishment of University Enterprises denotes an effort to institutionalize research commercialization. The next chapter in this dissertation will offer a more detailed description of University Enterprises and its role within the University of the Southern Hemisphere community.

University Enterprises has a total of 30 companies in its portfolio, which includes companies it actually helped found after the office was organized in 2003 as well as companies that self-founded or founded with little university involvement. Each of the 30 companies has some intellectual connection to the University of the Southern Hemisphere. With the exception of one firm that the university helped launch in 1978 before it routinely engaged in such commercialization efforts, each firm was launched in 1997 or later. Twenty-five of the 30 companies were launched in 2001 or later. Twenty of the 30 companies can be classified under the biotechnology or medical technology industries. The other industries represented in the University Enterprises portfolio are software (4 companies), materials (2 companies), imaging (1 company), audio technology (1 company), mining technology (1 company), and food technology (1 company). Six companies are publicly traded, and the remaining 24 are privately held. Each of the publicly traded companies was founded in 2001 or earlier.

I received the list of spin-off companies from the director of University Enterprises. During an exploratory visit to Australia in October 2007, I visited the University of the Southern Hemisphere and met with the director of University Enterprises in order to learn about the organization of the office and the companies in its portfolio. My visit to the University of the Southern Hemisphere enabled me to secure the support of University Enterprises in that the director agreed to provide me with any needed informational resources as well as any needed support in gaining access to the individuals affiliated with the spin-off companies. However the University of the Southern Hemisphere was in no way “engaged” in my research. This study was designed in order to minimize any undue influence by the University of the Southern Hemisphere or University Enterprises. There was no agenda on my part or on the part of the University of the Southern Hemisphere to influence the findings of this study.

Before beginning the interview portion of the data collection, I engaged in some preliminary background investigations on each company in my sample in order to familiarize myself with each one. During this process, I sought clarification on some of this background from the director of University Enterprises. This background investigation was critical in both determining my sample and arriving prepared and knowledgeable at my interviews (Hammer and Wildavsky, 2003).

Initial background investigation on each of the 30 companies in the University Enterprises portfolio indicates a high level of collaborative activity in the founding and continual operation of each venture. Many companies emerged from a variety of collaborative research efforts. Some companies emerged from research conducted by an established research lab in a given department at the University of the Southern Hemisphere. Other companies emerged from research conducted across multiple departments within the University of the Southern Hemisphere. And some companies emerged from research conducted by researchers at multiple organizations.

I selected six companies from the 30 companies in the University Enterprises portfolio. The selection of companies from the same university enables me to control for such factors as the university culture, norms, policies, and agendas as much as possible. Each of the companies in my sample is a biotechnology company, a medical technology company, or a company with business interests in at least one of these industries. Medical technology and biotechnology are interdependent industries in the life sciences that thrive on complementary knowledge. These industries contribute to a common regional economic capability (Brink, Dahlander, and McKelvey, 2007). Therefore, this selection of companies is appropriate, given the context of university's position as a leading biotech hub for the Asia-Pacific region and given biotech's position as a center of gravity for academic research commercialization activities. Table 3.1 offers an overview of the six companies.

Table 3.1. Sampled academic spin-off companies

Company name (pseudonyms)	**Year founded (IP origins)**	**Basic description**	**Company ownership**
Foxtrot Pharmaceuticals	2007 (2005)	Development of drug compounds for the treatment of fibrosis	Private – backed by venture capital
Delta Pharmaceuticals	2005 (2003)	HIV treatment	Private – backed by private investors and venture capital
Echo Technology Solutions	2004 (2001)	Digital pulse technology (medical imaging, mining, defense, materials analysis)	Private – backed by private investors
Beta Health Services	1999	Computerized cognitive tests for the pharmaceutical industry	Public
Alpha Pharmaceuticals	1997 (early 1990's)	Development of drug compounds for the treatment of neurodegenerative diseases	Public
Charlie Medical Technologies	2003 (mid 1990's)	Replacement sphincter for bladder control	Private – backed by venture capital

Qualitative case study methods

This research topic is appropriately answered through case study methodology because of the inductive theory-building nature of case study methods (Creswell, 2003, 1998). In contrast to theory-testing methods, theory-building methods fill in gaps where theories are missing and concepts are not fully explained. According to my literature review, the subjects of academic spin-off companies and academic entrepreneurship have gained recent traction in various areas of scholarship. Some recent and related studies (e.g. van Burg, Romme, Gilsing, and Reymen, 2008; Mosey, Lockett, and Westhead, 2006; Johansson, Jacob, and Hellström, 2005; Murray, 2004; Shane and Stuart, 2002; Lowe, 2001) employ qualitative methods.

Case study methodology enables me to confront emerging research with existing concepts, and it enables me to bridge a variety of concepts, theories, and ideas in novel ways. This is an attempt to do what Siggelkow (2007) notes are one of the aspects of case studies – "pointing to gaps and beginning to fill them" (p. 21). Additionally, higher education scholarship is less interested in this subject, and much of the complementary literature comes from disciplines outside of education research. This research is pursuing insight into complex social processes across multiple constructs – characteristics that favor case study methodology (Eisenhardt and Graebner, 2007).

The study of knowledge access, creation, and transfer is the study of unfolding social processes in academic spin-off companies, which appropriately lends itself to qualitative inquiry (Van Maanen, 1979). An underlying philosophy guiding this research is based on Van Maanen, Sørensen, and Mitchell's (2007) description of organizational research's aim to "speculate, discover, and document, as well as to provisionally order, explain, and predict, (presumably) observable social processes and structures that characterize behavior in and of organizations" (p. 1145). The literature review and the research questions cover the initial steps of speculation and discovery. The remainder of the dissertation process will cover the documenting, ordering, explaining, and predicting steps.

Data collection and analysis

Data collection

In order to collect interview data for each of the companies in my sample, I spent one month in Australia from November to December of 2008. During that time, I interviewed 15 respondents at their respective workplaces. I conducted interviews by phone with three additional respondents during July and August of 2009. Prior to my fieldwork in Australia, I identified an individual affiliated with each company who would serve as my respondent and initial point of contact at that company. For each case study company, I employed a snowball sampling method (Ortiz, 2003). In each case, as appropriate, the initial respondent referred me to other individuals who I eventually interviewed for my study. Because of the position of each of my initial respondents and their active status in each of their respective companies, I was able to receive "high quality referrals" through my sampling method (Hammer and Wildavsky, 2003). Each of the initial respondents was a company scientist with a University of the Southern

Hemisphere affiliation who played a key role in the development of a company's intellectual property.

The subsequent respondents consisted of individuals in a variety of roles associated with the various companies. Some individuals were academic scientists. Other individuals were non-scientists who held senior leadership roles in their respective companies. During my fieldwork, I had the opportunity to interview one individual from each of two separate venture capital firms that have invested in University of the Southern Hemisphere spin-off companies, including companies in my sample. Their responses enriched my understanding of the general context of spin-off companies, and they provided additional details about some of the companies in my sample.

In order to gain access to respondents who were not available during the time of my fieldwork in Australia, I conducted three additional interviews by phone during July and August of 2009. I identified one of these respondents through my snowball sampling methodology by using email contact to a previous respondent for a referral to a respondent. I arranged the other two interviews through direct contact with the respondents.

I interviewed a total of 18 individuals. The interviews followed a semi-structured protocol. The average interview lasted 54 minutes. The interviews ranged in length from 42 minutes to 81 minutes. I digitally recorded each interview. Each interview was professionally transcribed by an Australian transcription service. I selected an Australian service provider in order to minimize any difficulties with comprehending the accents of the participants. In order to protect confidentiality, I will refer to all company names and names of company officials and scientists through pseudonyms. Pseudonyms were randomly generated using an online application (http://www.kleimo.com/random/name.cfm).

Data also consisted of 287 company documents. I systematically collected press releases and annual reports for each of the companies in my sample. These materials came from publicly available online sources. Two of the companies in my sample are publicly traded. I used Australia Stock Exchange company filings to access documents for these two companies, which resulted in the availability of considerably more documents for these two companies than for the other four private companies. The two publicly traded companies were also the two oldest incorporated companies in my sample, which led to a longer history of available documents associated with each one. Table 3.2 describes the break down of data sources.

Table 3.2. Breakdown of data sources

Company or affiliation	Number of documents	Interviews
Foxtrot Pharmaceuticals	6	4 – 3 scientists; 1 non-scientist
Delta Pharmaceuticals	3	2 – 2 scientists
Echo Technology Solutions	9	2 – 1 scientist; 1 non-scientist
Beta Health Services*	98	3 – 2 scientists; 1 non-scientist
Alpha Pharmaceuticals*	164	3 – 3 scientists
Charlie Medical Technologies	7	2 – 1 scientist; 1 non-scientist
Venture capital professionals	N/A	2 – one from each of two local venture capital firms

*Denotes a publicly traded company

Analysis

I conducted preliminary analysis of my interview data during the course of my fieldwork in Australia. I listened to each interview and took very detailed notes from each interview. This process enabled me to generate specific follow-up questions about each company during the interviews with snowball-sampled participants. It also enabled me to get a sense of the whole and develop a general understanding of my interview data (Creswell, 2003).

My formal analysis consisted of coding the interviews and documents. I approached the coding process with a simple question of *what's going on?* (Charmaz, 2004). The initial process of open coding led to the emergence of themes that were both consistent with some of the original concepts of my dissertation proposal (Yin, 1994), and they produced new themes as well as a refined understanding of existing themes that I explored in my proposal. I gradually reduced the number of codes into meaningful categories that addressed the research questions. I treated writing as part of the analytical process (Coylar, 2009), often alternating between coding and writing in an attempt to make sense of my interview data.

I collected documents for each company and coded them in roughly the same way as I coded the interviews (Love, 2003). As with the interview coding, the document coding process yielded both new themes and refined themes with respect to my original dissertation proposal. Because many of the documents that came from the two publicly traded companies were reports written for an investor audience, I approached them with respect to the messages that they convey over time. I considered the *degree of condensation* within the documents to the extent that company information was compressed into somewhat vague language (Thomas, 1997), as is consistent with the press strategies of publicly traded companies. Ultimately, I considered many of these public company documents en masse rather than individually, in that much of the company information repeated from document to document. As such, the value of the large numbers of documents for these two companies is in their ability to show continuity and change over time.

Crafting the literature review was also part of the research design and analytical processes. The literature review was an active and ongoing part of my dissertation work that enabled me to enter the scholarly discourse around my chosen research topic and its supporting theories and concepts (Montuori, 2005). Prior to my fieldwork, I crafted a literature review that reflected my initial reading of the concept of academic research commercialisation from the organizational and knowledge transfer perspectives. In essence, the literature review enabled me to familiarize myself with my field and context of study, and it informed my research design (Boote and Beile, 2005). Upon completion of my fieldwork and throughout my coding and analysis, I continued to read and refine my literature review. An ongoing review of literature throughout the analysis of my data enabled me to make sense of the emerging themes and to ultimately craft a conceptual framework that would inform the reader of this dissertation of the knowledge being contributed through this process (Rocco and Plakhotnik, 2009; Reason, 2008). I treated the literature review and the writing of it as a critical part of the craft of my dissertation research study and the analysis of data (Coylar, 2009).

Reflexive self-awareness in the research process

The reflexive nature of qualitative research

One of the aspects of qualitative research is the involvement of the researcher in the research process (Goodwin and Horowitz, 2002). Qualitative case studies do not follow a positivist paradigm in which the researcher is completely detached from the research process. In the development of qualitative case studies, the researcher is not detached. In social research, the researcher uses research tools, and they, themselves, become research tools (Jenkins, 1995). Mauthner and Doucet (2003) note, "As social researchers, we are integral to the social world we study (p. 416). As such, they argue that researchers in the social sciences, particularly doctoral students, both influence and are influenced by their research. They propose the building of a certain level of reflexivity into the data analysis process.

The purpose of this section is to engage in reflexive thought and a process of self-awareness in order to determine my level of integration into the social world that I am studying. In a response to critiques about his book, *The Coming Crisis of Western Sociology,* Gouldner (1973) reengages his arguments about reflexivity in social research. He writes, “The lives of all serious sociologists are profoundly linked with their sociologies…there were indeed *men* behind the theories it criticized and this, after all, was the central thesis of the book” (p. 1079). In this spirit of Gouldner, I seek self-awareness about my role in the research in which I engage. I do so by discussing my role as both an insider and an outsider with respect to the research context and discuss how that role will influence the conclusions that I draw from my research.

Balancing insider and outsider perspectives

This dissertation is meant to carefully integrate and balance insider and outsider perspectives while leaning towards an outsider mode of inquiry. As a researcher, I am entering the world of academic commercialization and university-business relations to some degree as an outsider. I have never worked professionally in such a capacity. I do not have an insider’s perspective on the idiosyncrasies of academic research commercialisation, technology transfer, or new business development because I lack tacit working knowledge that only a professional would possess. I am not, however, naïve to this area of research. Previous research projects and professional conferences have put me in contact with numerous professionals from the field. My knowledge of the institutions of higher education and business provide me with a generalist's perspective of university-business relationships that allows me to make meaning of my experiences. Likewise, my decision to explore such relations in Australia adds another degree of complexity to my outsider status. As an American, conducting research in a foreign country makes me an outsider to the tacit understandings of the research context (i.e. Australian culture). On the other hand, I have travelled to Australia several times prior to and including the time spent conducting this research and established a professional network within the University of the Southern Hemisphere community.

The outsider's perspective in scholarship affords the researcher with a defamiliarizing experience, which elevates the researcher's mindfulness – or a conscious willingness to avoid simplified assumptions about the world (Weick and Sutcliffe, 2006). Daft (1983) argues that allowing room for error and surprise is a key feature to the craft of organizational research. Routines and assumptions would be embedded in a tacit working knowledge of academic commercialization, technology transfer, and new business development. This would subsequently guide my research in an overly familiar way and likely limit the necessary element of surprise. Since I am beginning with some degree of ambiguity in this subject area, my research design is meant for my findings to surprise me and lead me to learning something truly new. This dissertation is not meant to be so linear that it acts as nothing more than a problem solving project but rather it is meant to be more of a sensemaking exercise that can surprise and yield theoretical insights (see Weick, 1989). It also allows me to generate a certain degree of richness in my case study output. I employ my own requisite variety of theories, concepts, and ideas that can subsequently lead to rich insights without the clutter and bias of preconceived notions or assumptions about my topic (Weick, 2007).

Merton (1972) explored the differences between insider and outsider perspectives. According to Merton, “extreme insiderism” within scholarship is a form of “group solipsism” in which groups possess a monopoly of knowledge about themselves in which possession of that knowledge is a privilege unto itself. “According to the doctrine of the Insider, the Outsider, no matter how careful and talented, is excluded in principle from gaining access to the social and cultural truth” (p. 15). From a research perspective, maintaining some degree of detachment provides some level of objectivity in research in which myopia is minimized.

Merton illustrates how we are all insiders and outsiders in that everyone is a member of multiple groups, which form an individual’s “status set.” In this research, I am an insider to higher education, an insider to the vernacular of business, an outsider to technology transfer and new business development, an outsider to Australian society, and an insider to western culture. These characteristics give me what Merton would describe as “crosscutting” status in that these characteristics and my representative status in each overlap. My insider status within higher education, business vernacular, and western culture allows me to cope with my status as an outsider to technology transfer and Australian higher education. Ultimately I hope to achieve what Merton describes as a necessary role for social scientists. “The role of social scientist concerned with achieving knowledge about society requires enough detachment and trained capacity to know how to assemble and assess evidence without regard for what the analysis seems to imply about the worth of one's group" (Merton, 1972, p. 41).

Ultimately, this dissertation must contribute to higher education scholarship because of its genesis in a higher education program of study. That being said, one of the strengths of higher education scholarship lies in its interdisciplinary design that allows for a structured blend of insider and outsider perspectives that together facilitate the element of surprise inherent to an outsider's perspective with careful attention to the research trends of the field that an insider's perspective affords. This dissertation utilizes the outsider's perspective on two dimensions. From the research level of analysis, my position outside of the technology transfer profession and the country of Australia affords me the element of surprise that is necessary for yielding theoretical insights. From the meta-level, the research design of looking at academic spin-off companies from the outside by talking to people from business firms about the university will surprise me more than if I talked exclusively to people from within universities.

Theory construction

Plausibility

One of the goals of this dissertation is to develop theoretical propositions that are plausible, insightful, and surprising. Weick (1989) contends that the process of developing theory is akin to the art of "disciplined imagination" whereby "a good theory is a plausible theory, and a theory is judged to be more plausible and of higher quality if it is interesting rather than obvious, irrelevant, or absurd, obvious in novel ways, a source of unexpected connections, high in narrative rationality, aesthetically pleasing, or correspondent with presumed realities" (p. 517). When taking this approach to developing theoretical propositions, future researchers can presumably develop different follow-up questions more easily because conventional wisdom has been challenged.

Beyond the possession of some initial ideas, I approach this dissertation without any preconceived conclusions or anything that I am eager to prove or disprove. Although I begin this process with some initial ideas as well as some propositions that emerged within my literature review, I am open to this research process disconfirming some of these initial ideas. Disconfirmed assumptions offer new learning opportunities (Weick, 1989). Mintzberg (2005) writes, "Theory is insightful when it surprises, when it allows us to see profoundly, imaginatively, unconventionally into phenomena we thought we understood" (p. 361). Similarly, Merton (1972) articulates, "You have nothing to lose but your claims. You have a world of understanding to win" (p. 44). I seek to adhere to Kilbourn's (2006) assertion that dissertations should reflect 'genuine' inquiry that originates from ideas and haunches but seeks no agenda regarding the conclusion.

Qualitative research allows the theory building process to yield insights in a way that differs from the approach taken by quantitative researchers. Quantitative research uses methods to deductively validate claims made about a particular phenomenon.

Thus, theories that emerge from quantitative research are said to represent validated knowledge. However in social science research, the plausibility of a theory or proposition can substitute for validity (Weick, 1989). Van Maanen, Sørensen, and Mitchell (2007) argue that theorizing extends beyond the striving for validated knowledge. They write, "[T]he point of theorizing, when viewed as a cognitive process, is not simply to produce validated knowledge but, rather, to suggest plausible connections and relationships that have not yet been glimpsed" (p.1148). This relates to the approach to theory building as suggested by Weick (1989) and Mintzberg (2005). The seeing of things in ways that challenge our assumptions and the use of disciplined imagination is an inductive approach to theory building that can be achieved through qualitative research.

Middle range theorizing

As a dissertation, this research project is designed to catalyze future research about my topic. As a doctoral student, I do not intend for this dissertation to represent a culmination of sorts but instead lead to a productive research career. As such, my intent is not to "crack the code" of academic spin-off companies or propose a meta-level theory of academic spin-off companies. My goals are more humble and more pragmatic. My intent is to plausibly explain various aspects of university spin-off companies with respect to knowledge.

The goals of my dissertation research and the output I expect to achieve align with the philosophy of *middle range theorizing.* By using this as a guiding principle in the dissertation, I hope to minimize what Bourgeois (1979) suggests as a conflict in the broader behavioral sciences. One the one hand, theories developed at an unnecessarily high level of abstraction and distant from actual observations yield noncomparable findings. On the other hand, heavy empiricism "carries the risk of running rampant" (p. 443) while yielding nothing more than description. The research questions proposed in this dissertation are meant to be of manageable scope, which Weick (1989) argues is compatible with middle range theorizing.

Middle range theorizing is compatible with the careful management of insider and outsider perspective. Using Evered and Louis's (1981) distinction of insider and outsider modes of inquiry in organizational research, the aim of my inquiry falls somewhere between universality/generalizability and situational relevance. The type of knowledge I acquire will likely fall between universal theory and praxis. My methodology falls between completely detached neutrality and total immersion.

Improvisation and surprise

Creating a research environment from which one can be surprised and subsequently offer plausible middle range theoretical propositions can be achieved by practicing the art of improvisation. On some level, this dissertation is an exercise in improvisation that follows from Weick's (1998) essay on the relationship between jazz improvisation and theorizing. In jazz improvisation, musicians have "little choice but to wade in and see what happens. What will actually happen won't be known until it is too late to do anything about it" (p. 548). Theorizing has similar qualities in that the theorist uses the tool of sensemaking to see what exists in hindsight and to offer plausible explanations of what happened.

A dissertation is a bit like jazz improvisation. Like a musician's work, a researcher starts with something, not nothing. A musician may start with a melody. A researcher might begin with a theory, a conflict, a conjecture, or an idea. In this research, I am beginning with tenets of organizational theory that help in understanding academic commercialization and academic spin-off companies as well as a corresponding gap that needs further explanation. Improvisation creates conditions that surprise the musician or researcher. But musicians and researchers are skilled individuals who can take that surprise and respond creatively with their skill sets within a disciplined framework, or as Weick (1998) describes as a "flexible treatment of preplanned material" (p. 549). Improvisation allows for the end result of that first brush stroke, melody, or conjecture to be different each time it is engaged. No two dissertations are the same, but many originate from similar ideas based in similar bases of literature. But each researcher is an artist who improvises in a disciplined way toward a compelling end product. This dissertation is an exercise in these principles.

Limitations

Like any research methodology, qualitative case studies are subject to limitations. Sample size is an inherent issue with qualitative research. I have sought to balance the breadth of my data with the richness and thickness that stems from analysing a manageable level of qualitative data (Goodwin and Horowitz, 2002).

Generally, I sought to achieve a "large enough n" that was sufficient for answering my proposed research questions. I could always add "one more company" to my sample of cases, or I could always try to find "one more interviewee" to increase the richness of the findings. I was satisfied with my sample size when my analysis felt saturated and redundant and when I could offer a rich and structured analysis with the data at hand.

Generalizability is another inherent limitation to qualitative research. My study offers insight into knowledge creation in the context of academic research commercialization vis-à-vis spin-off companies. I sought to control certain "variables" of my research context by focusing my companies with activities in a shared industry (life sciences) and with connections to a common university. On the one hand, this potentially limits the conclusions of my study to this research context. On the other hand, well-articulated conclusions from this study offer directions for future research and form the basis of a line of scholarship. This is consistent with the theory-building nature of qualitative research. Additionally, this study was not designed as a consulting case, nor do I have any stake in the study's outcome beyond the discovery of meaningful insight. Therefore, I am not motivated to conclude with a set of best practices but can instead allow for plausible explanations that guide future inquiry.

Chapter 4 – The Case Study Context

The general context of the case studies

Overview

The case study companies to be presented in this dissertation are examples of spin-off companies associated with the University of the Southern Hemisphere. In order to effectively present the cases and offer an analysis of the various themes that cut across those cases, it is necessary to discuss relevant aspects of the context in which those companies operate. As such, the beginning three sections of this chapter focus on developing the context for the benefit of the reader.

The next section discusses the overall state of academic research commercialization in Australia with respect to overall commercialization trends and matters of intellectual property as they apply to academic scientists who are involved in commercialization efforts. Private sources of funding are a hallmark of the commercialization of academic research. As such, the second section discusses the overall aspects of private venture capital funding in Australia and the ways in which the needs of venture capital stakeholders drive the various elements of academic research commercialization with respect to spin-off companies. Finally, the third section will introduce the technology transfer office at the University of the Southern Hemisphere and discuss its role in academic research commercialization. The second half of this chapter introduces the six academic spin-off companies that are the subject of the study and offers the reader a general business description and scientific description of each company.

Academic research commercialization in Australia

Australian research universities are increasingly pursuing the commercialization of academic research as means to advancing the country's national system of innovation. The policies that guide academic research commercialization in Australia have both similarities and differences to those in other countries. On an international comparative scale, the commercialization of academic research in Australia falls between what Harman and Harman (2004) describe as top-down and bottom-up policies. They define a top-down policy approach as one in which government initiative heavily drives innovation policy and research commercialization. They define a bottom-up policy approach as one in which universities are competitive in the marketplace through their ownership of intellectual property. In their paper, they describe Swedish policy as top-down and characterized by government-led initiatives that discourage academic scientists from commercializing their research results. In contrast, they describe the United States as bottom-up and characterized by competition at the university level and university ownership of intellectual property as prescribed by the Bayh-Dole Act of 1980.

The ownership of intellectual property that is generated through the course of academic research has been subject to a variety of shifting policies in Australia. These policies have varied at the state and institutional level. According to Australian common law, employers assert the right of ownership to any intellectual property created by employees in the scope of their employment responsibilities. Australian universities have varied in their policies with respect to ownership of intellectual property generated by academic scientists (Harman and Harman, 2004). In 2000, the University of the Southern Hemisphere transferred ownership of intellectual property from the university to its academic staff. This policy was not been successful in catalysing innovation because it placed the burden of commercialization on the individual scientists who own the intellectual property. At the University of the Southern Hemisphere, the establishment of University Enterprises was meant to reduce this burden.

Today, University of the Southern Hemisphere intellectual property policy reflects several key changes. The university reversed its intellectual property policy in December 2007. As a result, from that point forward, the university owns intellectual property (scholarly works excluded) developed by its academic staff. This policy differs somewhat from that which applies to American universities. Under the Bayh-Dole Act, American universities own the intellectual property that results from academic research funded in any part by federal money. University of the Southern Hemisphere policy is more sweeping because it makes no distinction of ownership based on the source of research funding.

Venture capital in Australia

Academic research commercialization that occurs through the formation of a new spin-off company is heavily dependent on private money as a source of support for the ongoing research activities that are critical for the building of successful business ventures. Venture capital is the source of much of this private money. Venture capital firms are private investment firms that pool private financial resources – usually those of wealthy individuals – and invest those resources in new companies. Venture capital firms typically invest in a diversified portfolio of start-up companies in order to spread the risk of investing in such businesses. The expectation is that many new companies will fail within 3-5 years of their founding, but the few companies that don't fail will often lead to high rates of return for their investors.

Venture capital is an institutionalized means of private investment in start-up companies. In contrast, some wealthy individuals will directly invest their resources in new companies. These individuals are usually referred to as *angel investors*. Most of the companies in my sample received some form of venture capital as they were established and beginning to operate. Alternatively, some companies were solely funded by private angel investors.

Because venture capital is an institutionalized practice that can affect the momentum of an academic spin-off company, including aspects related to its knowledge development, it is important to discuss the general context of Australian venture capital as it applies to the cases in this dissertation. In order to understand the context of Australian venture capital, it is important to offer a brief review of the Australian innovation system and the efforts by the Australian federal government to catalyze business growth.

A recent paper by Lerner and Watson (2008) reviews the status of the Australian venture capital industry. They cite a 2005 Australian government report, which argues that the nation's venture capital industry was relatively "underdeveloped, showed low investment levels, a lack of capital formation and scale, and a very low number of investment managers with a proven track record" (p. 10). They also compare venture capital data from several mature market nations and find that Australia's venture capital market is relatively modest in size. They find that Australian venture capital lags behind that of developed venture capital markets such as the United States and the United Kingdom as well as behind that of emerging venture capital markets such as Canada, South Korea, and Sweden.

Of critical importance to the context of this dissertation research, Lerner and Watson note that the lagging venture capital market in Australia is not indicative of a lack of promising opportunities in academic science. Their data shows that Australia has a relatively high proportion of scientific publications relative to the size of the nation's population. It shows a respectable growth rate in the number of scientific publications emerging from Australian universities. However these figures, taken in the context of the relatively low level of venture capital investment in Australia, indicate a disparity between the innovative potential from academic research and the willingness to invest venture capital dollars towards the commercialization of that research. In other words, Australian research universities are an under-tapped market for possible investments by venture capital.

One of the respondents in my sample was a venture capital professional who works with a firm that has invested in University of the Southern Hemisphere spin-off companies. This individual has worked in both the United States and Australia and commented in a way that reflects Lerner and Watson's point about the under-tapped Australian academic market for possible investments.

> Yeah, I mean one of the advantages being down here [in Australia] is that the opportunities [are] not as picked over as it might be in Boston or San Francisco so there are generally new ground breaking technologies that exist here but just need to be commercialized in the right way (Respondent #7).

Similarly, an academic scientist who is a member of one of the spin-off companies in my sample noted:

> Well [the region] is, from an academic perspective I might say is probably a world leader in medical research. As far as venture capital, it's pretty isolated really (Respondent #15).

A 2005 policy report on Australia's innovation system that was commissioned by the Australia Department of Education, Science, and Training (Howard Partners, 2005) implies that Australian venture capital is somewhat risk adverse. They note that companies, which are candidates for possible venture capital funding, should fit an “ideal type” (p. 42) and that a disconnect exists between the ideal type of venture capital funding candidate and the reality of academic research results.

Some of the respondents in my study spoke of the Australian venture capital community with respect to their willingness to accept risk. One respondent noted:

> My experience recently has been that they are looking for later stage opportunities” (Respondent #12).

Later stage business opportunities have a lower risk of failure than early stage opportunities. Another respondent notes:

> I think that the Australian venture capital community is quite risk adverse and doesn’t seem to be sufficiently sophisticated enough yet to propose evaluations and strategies that address the inherent disconnect between what inventors are likely to value their technologies at, and what venture capitalists are likely to value their technologies at (Respondent #14).

A recent policy report (Cutler and Company, 2008) illustrates another challenge of Australian venture capital. The networks of Australian venture capital are not sufficiently linked to the networks of major American venture capital firms. The report notes that this trend is problematic in the raising of necessary downstream funding for entrepreneurial ventures. Herpin, Karuso, and Foley (2005) note that Australian venture capital firms lack the resources to provide additional follow-on rounds of funding that is necessary for many of their investee companies to succeed in the marketplace. In a sense, many entrepreneurial ventures, including those spun-off from universities, enter the marketplace with an insufficient amount of requisite capital funding.

These issues were evident in the analysis of one of the spin-off companies in my sample – Delta Pharmaceuticals – that I will further discuss later in this dissertation. Briefly, a group of Australian and American venture capital firms invested in Delta and provided it with funding for some of its early R&D work. Continued funding was contingent upon research results that satisfied the investors. One of the American venture capital firms was not sufficiently satisfied with Delta's results to provide additional funding, and the Australian investors did not provide follow-on funding.

In summary, venture capital firms provide entrepreneurial ventures such as academic spin-off companies with necessary funds to conduct costly R&D and develop their nascent businesses. Australia has an under-developed venture capital industry, which potentially hinders the transfer of academic knowledge from the university environment to the commercial environment.

University Enterprises – The technology transfer office

Academic research commercialization at the University of the Southern Hemisphere is currently managed through its technology transfer office – University Enterprises. University Enterprises is structured as a taxable private company that is a subsidiary of the University of the Southern Hemisphere. According to the 2008 University of the Southern Hemisphere *Annual Report,* University Enterprises earned $7.8 million in licensing income. A CEO leads University Enterprises and its staff of twenty associates spanning a variety of responsibilities. It consists of three primary functions – business development, new venture support, and asset management. The business development team provides a range of services that includes securing agreements with venture capital firms for investment in university spin-off companies, representing the university's fiduciary and investment interests on boards of spin-off companies, and the licensing of university technology to existing companies. The new venture support team is responsible for assisting university spin-off companies in a variety of operational capacities. The asset management team is responsible for managing the legal aspects of the intellectual property in the University Enterprises portfolio.

The current reporting relationship between the University of the Southern Hemisphere and University Enterprises is complex. University Enterprises is a subsidiary of UBIZ Pty. Ltd., a wholly-owned company of the University of the Southern Hemisphere that is responsible for each of the university's commercialization businesses, including consulting programs, and curriculum licensing.

A three-member board of directors oversees the CEO of University Enterprises. Currently, the board consists of the senior vice principal of the University of the Southern Hemisphere who is responsible for overall administration and management of the university; the deputy vice chancellor of research at the University of the Southern Hemisphere; and the vice principal of commercialization at the University of the Southern Hemisphere and CEO of UBIZ, Ltd.).

The reporting relationship between the University of the Southern Hemisphere and University Enterprises has changed since its founding in late 2003. The group that became University Enterprises was originally a division of Southern Hemisphere Extension (SHE). SHE was a separate, for-profit, private university that was affiliated with the University of the Southern Hemisphere and whose mission was to enroll fee-paying students and engage in other commercial activities. SHE was established in 1998, was closed, and many of whose activities subsequently merged with the University of the Southern Hemisphere in 2005 under UBIZ

University Enterprises was incorporated by SHE's Ventures and Investments Division on October 29, 2003. Prior to SHE's disbanding, the University of the Southern Hemisphere purchased University Enterprises. Ownership of University Enterprises was transferred from SHE to the University of the Southern Hemisphere on December 23, 2003. At that point in time, University Enterprises became a wholly-owned subsidiary company of the University of the Southern Hemisphere. The university's rationale for the purchase of University Enterprises was the consolidation of its research commercialization and technology transfer activities. As the university notes in its 2004 annual report, the purchase of University Enterprises "has enabled a greater focus and resourcing of the commercialization of the University's research activities" (p. 68).

On June 30, 2007, the university sold its shares in University Enterprises to its UBIZ subsidiary company. According to the university's 2007 annual report, the rationale for this change in the reporting relationship between the university and University Enterprises was to further streamline commercialization activities. The report's stated goal was to create a single management and governance structure for commercialization activities.

Based on the analysis throughout the course of this dissertation research, it is evident that the establishment of University Enterprises and the continued changes to its reporting structure represent a more focused emphasis on commercial activities – particularly the commercialization of academic research – on the part of the University of the Southern Hemisphere. The spin-off companies in my sample have founding dates that span almost a fifteen-year period. During that time, the university's role in research commercialization has evolved from one of ambivalence to one of active engagement. As such, the university's role as a facilitator of knowledge transfer has evolved. The interviews for this dissertation suggest that the leadership of the University of the Southern Hemisphere has varied in their prioritization of commercialization activities.

Prior to the 2003 establishment of University Enterprises, research commercialization at the university was scattered throughout the organization. The respondents who were involved in the founding of spin-off companies before 2003 generally described their experiences with the university in respect to commercialization activities as negative or, at best, ambivalent. Some respondents described the university's commercialization pre-2003 processes as "a free for all," "a nightmare," and "laissez-faire." Other respondents associated with more recent spin-off companies generally describe a more positive relationship with the university in respect to commercialization activities. These respondents were generally positive in describing their interactions with the staff of University Enterprises.

In summary, University Enterprises plays an important role in transfer of academic knowledge from the university to the commercial sector. In this dissertation, the role of University Enterprises in the development of academic spin-off companies will vary from case to case.

Date	**Event**
1998	Southern Hemisphere Extension (SHE) is established
October 29, 2003	University Enterprises is incorporated as a part of SHE
December 23, 2003	Ownership of University Enterprises is transferred to the University of the Southern Hemisphere
2005	University of the Southern Hemisphere closes SHE and transfers many SHE activities to a newly created subsidiary company, UBIZ
June 30, 2007	University of the Southern Hemisphere sells its shares in University Enterprises to UBIZ

Table 4.1 – Timeline of key University of the Southern Hemisphere commercialization activities

Introduction to the six academic spin-off companies

Alpha Pharmaceuticals

Alpha Pharmaceuticals is a company engaged in the development of drug treatments for neurodegenerative diseases, primarily Alzheimer's and Parkinson's disease. The company was formally established in 1997. Over the years, the company's

R&D has yielded a library of chemical compounds. Leading compounds have been subject to clinical trials. From 2000 to 2005, the company's first major chemical compounds progressed through various clinical trial stages, but further trials were suspended because of toxicity issues related to the compound. In 2005, the company launched clinical trials of its second, and current, leading compound. In 2008, it began to conduct pre-clinical testing of additional leading compounds.

The collective work of three scientists – Marlin Guitierez (PhD), Elwood Feagley (MD/PhD), and Rod Pfrogner (MD) – has largely comprised what has become Alpha Pharmaceuticals. Marlin Guitierez is a neurologist at a U.S. Ivy League University. Elwood Feagley is an Australian-based medical researcher with a specialization in psychiatry who completed his PhD at the University of the Southern Hemisphere under the supervision of Rod Pfrogner and who did his post-doctoral fellowship under the supervision of Marlin Guitierez. Rod Pfrogner, trained in medicine and pathology, is a researcher at the University of the Southern Hemisphere who has spent much of his career researching Alzheimer's and other neurodegenerative diseases.

The work of these three scientists has collectively centered on the amyloid precursor protein (APP) as the gene associated with Alzheimer's disease. The APP gene has been shown to have metal-binding sequences, thus suggesting that Alzheimer's disease is a disease of metal toxicity in the brain that occurs when naturally occurring metals in the brain bind with the protein to form plaques. The chemical compounds that Alpha has developed and is testing are aimed at dissolving the plaques that form in the brains of patients with Alzheimer's disease. Alpha's work is also aimed at studying these same compounds in the treatment of other neurodegenerative diseases that are believed to be caused by metal toxicity.

Beta Health Services

Beta Health Services is a medical technology company that specializes in cognitive testing services. The company was founded in 1999. It licenses the use of its cognitive tests to customers and provides them with end-to-end support such as the management of real-time testing data. Its cognitive tests are sold to four major markets. The first is its clinical trials market in which the company licenses its cognitive tests to large global pharmaceutical companies for use in clinical trials. The second is its academic market in which the company licenses an academic version of its tests to university researchers. The third is its sports market in which the company licenses its tests to sports teams and sports clubs in order to determine cognitive change in athletes suffering concussion. The fourth is its workplace market in which the company licenses its tests to occupational health professionals.

At one point, Beta also engaged in the drug development business. The company in-licensed intellectual property associated with a Parkinson's project and an Alzheimer's project from other biotechnology companies. Much of the work for these projects was subsequently contracted to scientists in external labs. The company's role in these projects was mostly project management. The company divested these drug development projects in 2005 in order to remain focused on its core competency – cognitive test development.

Gordon Kirts (PhD) and Lewis Caples (PhD) are Beta's scientific co-founders. Gordon Kirts is a neurologist who worked at the University of the Southern Hemisphere who had a secondary interest in computer programming. As a result of these combined interests, he recognized the potential for computerized tests of cognition. He also recognized a niche for an effective test that could measure cognitive change in people over time. He collaborated with a colleague, Lewis Caples, in the founding of the company. Lewis Caples is a neuropsychologist who had previously worked at the University of the Southern Hemisphere and was a professor at another local university. The two scientists initially met one another at a neuroscience conference.

Charlie Medical Technologies

Charlie Medical Technologies (CMT) is a medical device company whose technology is applied to incontinence care. The company was formally established in 2003, however the genesis of the company dates to the mid 1990's. During the mid 1990's, a group of researchers in the department of anatomy and cell biology had an idea for the use of smooth muscle as a replacement sphincter. The subsequent development of the replacement sphincter represents the basis of the company's current core technology. The company's ColoNovus device is currently undergoing clinical trials in Australia and is aimed at treating urinary incontinence. The company's FaecalCare System is a computer-based device that removes and disposes fecal waste and is used in patients who have had a colostomy.

The original group of University of the Southern Hemisphere scientists who were involved in the early work on the development of the replacement sphincter formed a small company called F5. F5 secured about $1 million in funding from government and private sources so that they could conduct some pilot studies. The initial pilot studies were conducted in the founders' lab at the University of the Southern Hemisphere. After two and a half years of pilot studies, F5 needed to raise more money, so they partnered with a large Australian medical devices company called Gamma Industries.

F5 and Gamma formed a collaboration based around access to Gamma's implantable electrical stimulation technology, which was necessary for the further development of the replacement sphincter. Gamma was interested in the technology that F5 was developing. At that time, Gamma had a technology for spinal cord injury, and the company was looking to further the application of that technology. As a result, Gamma became interested in continence control as a potentially treatable condition of people suffering from spinal cord injury.

Echo Technology Solutions

Echo Technology Solutions is a diversified technology company that focuses on pulse processing technologies for the rapid, accurate detection and measurement of radiation. It was founded in 2004. The company's core detection technology is applied to business activities in four major categories – medical imaging, defense and security, minerals exploration and analysis, and materials analysis. In the medical imaging sector, the company's technology is applied to increase the resolution, speed, and accuracy of medical images while reducing patient exposure to radiation. Likewise, the same concept applies to the company's defense and security business sector in that the technology seeks to increase the resolution, speed, and accuracy of the cargo screening processes in air and sea ports. In the minerals exploration and analysis (mining) sector, the company's technology enables faster and more accurate detection of minerals with deeper geologic penetration and light equipment loads. Finally, the company's technology is applicable to other industrial applications requiring accurate analysis of materials.

Echo Technology Solutions originated from research efforts at the University of the Southern Hemisphere. Company founder Rick Avans (ABD) started a PhD program in electrical and electronic engineering at the university. His initial research efforts focused on detection technologies in the context of humanitarian land mine clearance. His research efforts initially used several detection methods, but he encountered similar shortcoming across each method. Specifically, most detection methods were limited to either very low signal strength that yielded slow or inconclusive results, or there were high signal strength methods that yielded corrupted results. His subsequent research efforts sought to improve the accuracy and speed of gamma ray detection. The technology that ultimately underlies the intellectual property at Echo stems from the improved detection methods developed during his doctoral program.

Delta Pharmaceuticals

Delta Pharmaceuticals is a biotechnology company focused on the development of novel therapies for HIV and Hepatitis C. The company, which stemmed from research at the University of the Southern Hemisphere department of microbiology and immunology, was started in 2004. The company is currently engaged in advanced animal studies, which are being conducted in anticipation of human clinical trials.

Wesley Chabot (MD) is a researcher and head of a lab in the University of the Southern Hemisphere department of microbiology and immunology. In 2003, he was working with a post-doctoral scientist to develop an assay system (a procedural test) for the measurement of a type of immunity in monkeys. They realized that the injections they were making in the monkeys in the process of developing the assay were actually enhancing the immunity in the monkeys. In other words, the development of the assay for the measurement of immunity led to a serendipitous discovery of an increase in actual immunity.

Foxtrot Pharmaceuticals

Foxtrot Pharmaceuticals is a biotechnology company that is currently engaged in pre-clinical-trial phase research on drug compounds that have the potential to treat fibrosis that occurs in such chronic diseases as kidney disease, heart failure, pulmonary fibrosis, and arthritis. In short, fibrosis is the irreversible scarring of tissue, which reduces the ability of organs to properly function. Foxtrot is a young company – founded in mid 2006.

Members of the company's scientific team are based at a University of the Southern Hemisphere multi-disciplinary research institute known as Veritas (pseudonym). Tim Holford (PhD) is a chemist who runs an organic chemistry lab that makes chemical compounds. Maurice Gillock (PhD) is a senior research fellow who also runs a lab at the Veritas in the area of biochemistry and molecular biology. Jerold Carlsten (PhD) is a medical researcher who works at a local hospital that is affiliated with the University of the Southern Hemisphere's department of medicine. Initially, Jerold Carlsten was working with an off-patent drug from Japan and South Korea that was believed to demonstrate anti-fibrotic qualities. He approached Tim Holford about the possibility of developing some drug molecules in an attempt to increase the potency and novelty of the drug. Maurice Gillock facilitated the connection between Jerold Carlsten and Tim Holford. When Jerold learned that Maurice was relocating to the Veritas, he asked Maurice if he knew any chemists who could collaborate on the drug project, so he subsequently introduced Jerold to Tim.

In addition to these individuals, Jerold Carlsten also had research collaborations with two other scientists who have subsequently worked with Foxtrot. One is currently a clinical endocrinologist and medical researcher in Canada and a former University of the Southern Hemisphere professor. The second is the head of the clinical pharmacology unit at another Australian research university and has experience in the design of clinical trials.

Foxtrot is the product of multi-disciplinary science. In general, Tim's lab is involved in the development of drug compounds. Those compounds are then periodically transferred to Jerold Carlsten's lab for proof of concept studies in animal models and cell culture models. The other scientists consult on matters of clinical significance.

Chapter summary

This chapter has discussed various contextual aspects that will apply to the specific case study spin-off companies, which will be developed in the upcoming chapters of this dissertation. In summary, local aspects of the university environment, and broader policy and business market aspects at the national and international levels affect the activities of the academic spin-off companies in this dissertation. The Australian venture capital industry as well as the University of the Southern Hemisphere's research commercialization efforts will play an integral background role throughout this study.

Table 4.2 – Chapter summary table

	Year founded (origins)	Basic company/science overview	Organizational structure and geography	Ownership and funding	Intellectual property	Academic relationships
Alpha Pharmaceuticals	1997 (early 1990's)	Development of drug compounds for the treatment of neurodegenerative diseases	13 local employees; current and past clinical trial sites in Australia, Boston, London, and Uppsala (Sweden)	Public	22 patents and patent applications; library of 400+ drug compounds	Key relationships with the University of the Southern Hemisphere, a U.S. Ivy League University; active academic publications and presentations
Beta Health Services	1999	Computerized cognitive tests for the pharmaceutical industry	30 mostly local employees; second office in New Haven; active student internship program	Public	Patents on its cognitive test application; much tacit expertise	Various ties to the University of the Southern Hemisphere and other American universities through connections to individual researchers and post-docs; active academic publications and presentations
Charlie Medical Technologies	2003 (mid 1990's)	Replacement sphincter for bladder control	3 national employees; 8 board members; local and national R&D activities	Private – backed by venture capital	One patent granted each in Australia and the U.S.; 10 currently filed patent applications; tacit expertise developed in partnership with Gamma and FaecalCare	Key research contracts with the University of the Southern Hemisphere; limited relationship with University Enterprises over IP matters; restricted academic publications and presentations
Echo Technology Solutions	2004 (2001)	Digital pulse technology (medical imaging, mining, defense, materials analysis)	3 local employees; 1 non-executive chairman	Private – backed by individual private investors	1 Australian patent	Informal relationships with the University of the Southern Hemisphere; limited recent academic presentations
Delta Pharmaceuticals	2005 (2003)	HIV treatment	Drug development work is conducted by a 6-person, globally-dispersed project team	Private – backed by venture capital and philanthropic support	At least 2-3	Research contracts with the University of the Southern Hemisphere; academic publications and presentations; University Enterprises helped the company attract venture capital investors
Foxtrot Pharmaceuticals	2007 (2005)	Development of drug compounds for the treatment of fibrosis	1 CEO; 4 board members; 4 scientific advisory board members; mostly local	Private – backed by venture capital	Library of 50+ drug compounds; 3 pending patent applications	Embedded relationships with Veritas; University Enterprises plays an active role; ties to key scientists in Australia and Canada; no active academic publications or presentations

Chapter 5 – Academic Spin-off Companies as Virtual Companies

Introduction

This chapter presents two companies – Delta Pharmaceuticals and Charlie Medical Technologies – whose social structures most closely resemble that of an archetypical *virtual company,* with ambiguous organizational boundaries and loose coupling among its members. These features complicate the observation of such companies such that the companies defy the otherwise pedestrian view of an entrepreneurial venture. One does not simply walk into a company whose structure is virtual, as there are no specific offices or labs per se. Instead, the observation of an academic spin-off company with a virtual structure evolves into an exploration of a major project. In the case of the two companies presented in this chapter, the "company" was a social structure organized around a commercially funded R&D project that sought to bring a therapeutic drug or medical device to market with the goal of helping people with certain medical conditions. Additionally, the companies in this chapter were not entirely "spun off" from the university in that the social organizational structure of each company blurs with that of the academic environment.

The two companies discussed in this chapter were founded for similar reasons and with similar goals. Each company's respective founders recognized an opportunity to apply academic knowledge to the development of medical treatments. For Delta, the founders organized around an R&D project to bring an HIV drug treatment to market. For CMT, the founders organized around an R&D project to bring a medical device for the treatment of continence control to market. Commercialization provided the founders of each company with funding and collaborative resources that enabled their respective R&D projects to materialize. Strategically, both companies are organized as speculative R&D projects. The projects are exploratory in nature in that the final efficacy of each project is not yet determined – Delta's HIV treatment and CMT's replacement sphincter are still under varying stages of clinical trials in order to ascertain if they will safely work in humans. Each company has intellectual property around their respective projects, but they have few resources that they can exploit for revenue in the marketplace. Therefore, the academic credibility of each R&D project is, to varying degrees, a legitimizing aspect of each company that enables it to continuously attract funding in support of its mission. Each company maintains idiosyncratic relationships with the University of the Southern Hemisphere, as the source of each company's academic legitimacy varies across academic networks. However the virtual structure of each company blurs the boundary between themselves and the university.

Delta Pharmaceuticals

Goals and strategies

Strategically, Delta is organized around the exploration of new knowledge (March, 1991). Like other drug development projects, Delta's project for the development of an HIV treatment is long-term. It requires animal tests and multiple rounds of human clinical trials. Strategically, the company has few, if any, knowledge resources that it can currently exploit for revenue. It does own intellectual property that it could exploit if the drug development is ultimately successful or could attempt to sell or license if the project ultimately fails. The company's affiliations with the academic community as well as its scientific productivity are leveraged for the purposes of gaining additional funding from investors. Beyond this, Delta is a speculative R&D project.

Delta is a virtual company. The company itself is an ownership structure among its investors that owns intellectual property. Two American and two Australian venture capital firms provided the first round of funding for Delta's project. There is a distinct separation between the company and its actual drug development project. Delta, as a company, has no discernable operations. However Delta, as a drug development project, has a discernable project team and operations. BioMedicine Services Pty. Ltd. (BMS) (pseudonym), a local drug development service company, is an operational proxy that coordinates the Delta project's loosely coupled R&D on behalf of the Delta investors.

Delta founder Wesley Chabot had a connection to Jackson Dellow, who is the founder and director of BMS. BMS became involved when Delta was beginning the commercialization process and seeking to raise funds from venture capital firms. BMS became the operational entity behind Delta. Once Delta received its first round of venture capital funding ($6 million), Wesley Chabot's lab at the University of the Southern Hemisphere was engaged in a major animal study in the development of the HIV treatment. Subsequent funding for Delta came through a philanthropic channel that was arranged through BMS and a major American Research University (ARU) with an affiliated medical center. Upon the solidification of this new $4 million funding arrangement with ARU, BMS shifted its reporting relationship from Delta to ARU and subsequently assumed the drug development role. Wesley Chabot's lab at the University of the Southern Hemisphere had no further involvement in the Delta project after 2007, although Chabot is occasionally consulted.

BMS currently operates the Delta project under a funding contract from ARU. BMS manages a six-person project team that is globally dispersed. The project team consists of functional area representatives, a regulatory expert, a clinical expert, a toxicologist, and a basic researcher. BMS also maintains a global network of experts that it consults on behalf of the Delta project as needed. The corporate entity of Delta is incorporated in both Australia and the United States for the purposes of its venture capital investors who are located in each country.

The company's current structure is a function of both the institutional constraints of the commercial marketplace – as exhibited by investor's monetary influence over the drug development project – and the academic scientific community that has played an instrumental role in legitimizing and sustaining the company's R&D. This consequent structure of the company has yielded new knowledge, despite the company's inability to generate a financial return for its investors up to this point in time. Because the Delta drug development project has progressed in a linear fashion among various stages, knowledge has been codified and distributed among the parties involved in each stage. BMS – in its role as project manager for Delta's drug development project – has played an important role in assimilating, organizing, and distributing knowledge throughout a global network of epistemologically diverse experts that have contributed to this project. Thus, the Delta virtual company structure is a function of requisite epistemological diversity and multi-institutional pressures, which has led to the creation of knowledge as evidenced by the rhythm and order of the project team.

Epistemological factors

One of the factors behind Delta's virtual structure is the global distribution of the independent experts and intellectual diversity that BMS has assimilated for the company's R&D. Much like the Human Genome Project (see Powell and Grodal, 2005), Delta is a loosely coupled confederation of scientists, each of whom have independent affiliations to other organizations and institutions. By virtue of this structure, each participating scientist is a bridging tie (Fleming and Marx, 2006; Burt, 1992) between

Delta and other institutions, which enables Delta to cast as wide a net as necessary in pursuit of knowledge resources.

The global nature of the project team enables BMS to assimilate the most relevant knowledge and expertise for the purpose of advancing the project. This form of organization provides Delta with flexibility as the project evolves among various stages. Through its coordinating role, BMS captures knowledge of the participating parties and transfers it to subsequent parties as needed. The research group had been based in Denmark and is now located in the United Kingdom. The clinical group is based in London. The manufacturing group was based in San Francisco and is now located in Belgium. The toxicology expert was previously based in the United Kingdom and is currently based in Australia. Researchers from ARU in the United States serve as scientific advisors.

Despite the origins of the company in a University of the Southern Hemisphere research lab, Delta's relationship with the University of the Southern Hemisphere as a source of knowledge resources has gradually abated since the company's founding. The changing nature of this relationship reflects the both the company's funding structure as well as the stage of the company's drug development project. Upon the formal incorporation of the company and the receipt of the first round of funding for animal tests, Wesley Chabot's University of the Southern Hemisphere lab was the base of the company's research activities. His research lab focused exclusively on the project. These researchers analyzed blood samples from monkeys that came from an on-campus primate lab. Everyone in the lab, including students and post-docs, committed research efforts to the project that was now funded under contract by the investors in Delta, which blurred the boundary between academic and company research. For example, doctoral students in the lab who were involved in the project could use data in their dissertations, but agreements with the company required that publication of a dissertation using company data be delayed for one year. Wesley Chabot's lab completed the first round of funded research, but subsequent rounds of investor funding were not immediately secured because of one investor's reluctance. As a result of this funding shift, the social structure of Delta and the R&D project shifted and did so in a direction that reduced the role of the University of the Southern Hemisphere as a source of knowledge.

The role of Wesley Chabot's lab changed as the funding structure of the company shifted. When one of Delta's investors decided to suspend the funding of the project, the company's operational team from BMS sought input from outside experts about the viability of the project and potential future courses of action. The search for experts went beyond the University of the Southern Hemisphere and extended through BMS's global network of ties. Through BMS's network, Delta secured the support of an investor and a research group at ARU. The ARU group provided a knowledge base that complemented the resources that BMS had assimilated and increased the requisite variety of knowledge resources (Weick, 1979; Ashby, 1956) available to the project team.

> When we were talking with ARU, our (BMS's) skills don't overlap at all; ARU is an excellent group of research physicians and also have very strong immunology,

primary immunology, knowledge. So, and our expertise is in the conduct of development programs from manufacture through (toxicology) and into the clinic. So the skill set really complemented itself very well and no one I don't feel I can be a better HIV physician than they are and they don't think that they're better developers than we are. So we actually work together really well as a result of that (Respondent #18).

Delta's current structure as a virtual project team is globally dispersed and operates on a rhythm, which is focused on the development of the project (Bauer, 2007). The work conducted under the direction of Wesley Chabot's lab at the University of the Southern Hemisphere focused on animal studies. Subsequent steps under the project team structure consisted of the manufacture of a drug and corresponding toxicology studies. The researchers affiliated with ARU have taken part of the Delta project under development as an HIV treatment for developing countries. The project team members belong to other respective institutions, and BMS acts as the coordinating entity that connects the members of the project team and acts as the focal point of the project team network. The project team meets in person on an annual basis, which provides a touchstone for the rest of the time when members of the team communicate through virtual methods.

[The virtual project structure is] fairly standard methodology. And we have functional area representatives who sit on the project teams and we have a regulatory person, a clinical person, a toxicologist, a basic researcher and then

> you know we have other functional expertise come to the table as we need to. And we (BMS) run all of those project team discussions, we have formal meetings once a month and we do that via teleconference calls... So you know we've got people all over the planet who are inputting into the development of this product and so that's how we run our program (Respondent #18).

The changing role that a single university research lab can play in a drug development project like that of Delta also reflects the stage of the R&D. In the case of many academic spin-off companies, the scientific founders and the managers of the company differ with respect to their views about the role that academic scientists should play in the venture. In Delta's case, an academic scientist expressed frustration with the stage-gating of the project and would have preferred that the investors concurrently fund each stage of the R&D, while a manager indicated that the role of academic scientists changes when the company reaches the development phase.

> I think things would have gone quicker if the VCs had funded it all the way through clinical trials because it came to a decision, 'Fine, what should we do now?' (Respondent #10).

> So I guess that the key emphasis is when you're in development, there's often very little that an academic group can bring and that's a terrible gross overstatement but it might give you an idea of how I view this sort of activity. Academic groups are really good at you know research questions with an open-

ended outcome, potentially. They are really poor at specific development activities (Respondent #18).

Consequently, Delta's R&D project and its knowledge base – while rooted in academic science – is no longer embedded in a single university or disciplinary community. As the company's structure has evolved and has assumed the form of a virtual project team, the distinction between academic research and commercial activity is clearer. Academic scientists are conducting a smaller proportion of the Delta project work. Likewise, as the project shifts from research to development, industry experts are assuming a greater proportion of the work.

Institutional factors

Institutional factors have impacted the structure of Delta, especially its shift from a local lab-based structure to a global virtual structure. Delta represents an interesting example of an academic spin-off company whose academic credibility was questioned. Scientists affiliated with the American Research University and its affiliated hospital reaffirmed the academic credibility of the Delta project, which subsequently expanded the company's network structure and shifted it to its present structure as a virtual company. The company's academic credibility is rooted in the network of scientists that contribute to its R&D. This academic credibility enables the company to receive funding, which strengthens its overall legitimacy.

In the case of an R&D project that is based on the exploration of new knowledge and the speculation of a long-term commercial payoff, the actions of investors can greatly influence the nature of scientific work. This represents an example of commercial institutional pressures limiting Delta's academic activities (Berger and Luckmann, 1966) in that the pressures to minimize an investor's commercial risk interfered with the company's scientific objectives. A threat of discontinued funding after the initial round of VC-funded animal tests, which was the result of investor dissatisfaction with research results, nearly derailed Delta. Wesley Chabot's lab received funding from a combined pool of four VC firms for the purposes of conducting the first round of animal tests and determining the efficacy of the proposed HIV treatment. The results of the lab work conducted by Wesley Chabot and his colleagues indicated that their treatment delayed AIDS and demonstrated a ten-fold reduction in viral load. However, one of the U.S. VC firms was less enthusiastic about the results.

> "One of the venture capital groups, one in the US, felt – sent this data out for external research and felt that it was maybe not enough, that it wasn't as spectacularly successful as they'd hoped. We were all pretty excited about it because I thought it was a good result" (Respondent #10).

In an effort to determine next steps and to reinvigorate the project, Delta underwent a subsequent sequence of events in which BMS ascertained the project's credibility by meeting with outside research experts while securing a $4 million investment that reflected investor confidence in the scientific potential of the R&D

project. BMS engaged in a worldwide effort to find additional funds by speaking to other academic scientists in order to determine the long-term scientific potential of the project. In essence, BMS was seeking to ascertain the academic legitimacy of the Delta drug development project. BMS was successful in finding a new source of funds, and arranged a complex funding structure that involved the Amercian Research University and its affiliated hospital. The Australian and American VC firms that initially invested in Delta's first round of R&D were able to see a continuation of the company's R&D efforts without having to invest additional money. To be considered a viable R&D stage commercial entity and to sustain its commercial legitimacy, Delta required a stronger degree of academic legitimacy. These actions illustrate how academic and commercial legitimacy are not mutually exclusive.

> The priorities of VCs change over time and if you, no matter how clearly you lay out a plan that seems logical – if you achieve this, you achieve this, you achieve this, you achieve this, and then you keep going forward, but they can just say, 'Well, we're just not going to put anymore money in this.' It's not a – it's a commercial decision and they have other priorities (Respondent #10).

In an effort to signal the academic credibility, Delta has remained relatively transparent to the academic community, which has strengthened the overall legitimacy of the company. In addition to BMS's efforts in recruiting scientists to participate in Delta's R&D (their participation thus provides the company with a vote of academic confidence), the company has signalled its academic credibility through traditional academic channels. Research results related to Delta's R&D have been widely disseminated through conferences and publications. The company has maintained a policy of open dissemination of knowledge provided that research results are initially reviewed for intellectual property concerns and subsequently protected as necessary. As is the case with the other companies in my sample, academic legitimacy is an important aspect in the raising of funds. In this case, academic legitimacy was especially important in raising a necessary second round of funds to support the continued R&D of the Delta drug development project.

> If we were you know going out to talk to investors, they often want external validation of your data and that comes in a couple of forms: one is in a well-convened and credible scientific advisory board where people can basically say, 'Look, we think there's something in this' and then secondly, in peer-review publications because, you know, that's a means of putting to the world that you've got, you know, something that you're prepared to share and that the methodology or the intellectual property has some merit to it (Respondent #18).

Venture capital professionals interviewed for this study articulated similar trade-offs between the balancing of intellectual property concerns with the value that is gained from disseminating research results. One individual summarized this generally shared perspective.

> Yes, that's something that needs to be managed pretty closely. There's two sides of that obviously, first of all the company is funding the work, funding the pattern prosecution, yet the core asset is the intellectual property in most of

> these companies so that has to be managed and controlled pretty acutely, so there's no problems with inappropriate early disclosures which can ruin the IP position and therefore ruin the prospects for that technology to be developed, but that's on the one hand, on the other hand there's nothing stronger than having a technology which has strong data, strong IP position and externally validated peer review publications, so its really a timing issue (Respondent #7).

The global academic community – as opposed to the local affiliation with the University of the Southern Hemisphere – has been the source of Delta's scientific credibility, which has subsequently solidified its commercial legitimacy as an R&D-stage venture. Despite this, the University of the Southern Hemisphere did play a role in the company's commercialization. Delta is a private company backed by venture capital. University Enterprises helped the company founders present funding proposals to venture capital groups. A certain Australian venture capital firm was not interested in being a sole investor because, by the time of the presentation, the technology had advanced beyond the seed stage during which they would usually invest. Yet Wesley Chabot's research group needed funds to conduct another battery of expensive tests. So University Enterprises helped arrange additional funding with a major Australian venture capital firm. University Enterprises then helped Delta secure additional funds from two United States venture capital firms in anticipation of future human clinical trials. United States venture capital was sought because venture capital funding for more expensive phase one and phase two clinical trials is not as readily available in

Australia as it is in the United States. By October 2005, the four venture capital firms had contributed a total of $6 million to Delta. In essence, University Enterprises championed the company by enabling the investors to understand its potential.

Because of the speculative nature of Delta's R&D, investors in academic spin-off companies like Delta require intellectual property protections, which provide them with knowledge assets to exploit as necessary. University Enterprises helped the company in securing intellectual property protections, which further symbolizes its commercial legitimacy. In 2004, with the help of University Enterprises, Wesley Chabot filed a provisional patent on his research. Delta Pharmaceuticals owns the intellectual property, but it granted a license to ARU for the purposes of the ongoing R&D. These protections have enabled the subsequent publication and presentation of academic papers based on Delta research.

University Enterprises did play a number of roles in helping Delta file its intellectual property protections and arrange venture capital financing (Jain, George, and Maltarich, 2009; Wright, Lockett, Clarysse, and Binks, 2006; Colyvas, et al., 2002). BioMedical Services also played an important role by serving as the operational team that championed the enterprise, which would bring commercial discipline to the company in order to help attract investors. The presence of BMS as an operational team behind Delta is a symbolic action of order and commercial discipline that can bring legitimacy to the company from the perspective of investors (Zott and Huy, 2007). The actions of University Enterprises and BMS helped Delta navigate the commercial institutional terrain and ultimately achieve a balance between academic and commercial legitimacy.

Creating knowledge

Knowledge creation at Delta is discernable in two major ways. The first was when the company's R&D was localized in a single lab at the University of the Southern Hemisphere. This structure enabled "bench level collaboration" (Zucker, Darby, and Armstrong, 2002) and the mutual sharing of tacit knowledge and the codification of this shared knowledge in to something explicit. Codification was evident in that research publications emerged from this shared work, and knowledge resources were sufficiently transferred when the R&D shifted away from the original lab.

The second discernable aspect of the company's knowledge creation was when BMS reorganized the R&D as a virtual project team and assumed the role as the coordinating mechanism through which knowledge was codified and transferred among participating scientists. As the coordinating entity behind the Delta project, BMS played an important role of transferring knowledge and determining which aspects of knowledge were relevant for other parties. This was evident in the shifting of the project from Wesley Chabot's lab at the University of the Southern Hemisphere to the American Research University.

> Because the R&D knowledge associated with the company now resided with us (BMS), when we went off to work for ARU we basically took all of our knowledge associated with the manufacture and the technology with us. So there wasn't

> much of a need for some of the primary research information to be transferred over; we already had all the reports and documentation and knowledge about it. So it was very much as a service provider that they were engaged and there wasn't a lot of scientist-to-scientist interaction... I mean, it went extremely well; it went – there was almost no hesitation in time and activities because we had the same team in-house at BMS and then we just applied those people to – you know, and the learnings that we had, to our new contractors. (Respondent #18).

BMS's coordinating role on behalf of Delta creates order from an otherwise disordered structure, and in doing so it organizes to create knowledge and achieve *closure* in the hand-offs among members of the virtual project team (Patriotta, 2003). The progression among stages in the project represent closure in the sense that one group completes its part and then hands off what it learned to the next group. This was evident in the in the shift between the work conducted in Wesley Chabot's lab and the subsequent hand off to members of the virtual project team that BMS organized on behalf of Delta.

> I think for us the recognition that the technology has a life of its own and it's been carried forward into clinical trials by people who are hopefully good at that, that allows us to step back from it and do the things that we are good at (Respondent #10).

The Delta drug development project has progressed along a series of steps. Each step represents closure and passes knowledge to the subsequent steps. In the case of Delta, the drug development project progressed from animal studies, drug manufacture, and toxicology studies. At the time of this writing, Delta was preparing to enter human clinical trials. One of the respondents sums up the knowledge creation process in this sort of drug development project.

> It's a long process in my view, and it's just a lot of little steps. Sometimes what you're doing has a direct path that way, and then other times your bit of knowledge contributes to someone else's bit of knowledge that eventually finds its way to some sort of clinical outcome or community outcome (Respondent #10).

Delta was commercialized and organized to address a specific R&D challenge – the development of an HIV treatment. HIV is a devastating virus that continuously challenges scientists in the search for efficacious treatments. Knowledge about HIV is generated in the search for treatments. The disease continues to challenge scientists and other researchers, and it is this ongoing activity that enables knowledge to be created.

Because the viability of Delta's R&D project is subject to its ability to raise money in support of the project, the knowledge that the company ultimately creates is subject to the value that its investors perceive. Thus, knowledge creation at Delta is situationally contingent upon the institutional dynamic among academic scientists, investors, and managers (Knorr-Cetina, 1981). Either party can influence or constrain the R&D and, therefore, impact the creation of knowledge.

Charlie Medical Technologies

Goals and strategies

Charlie Medical Technologies (CMT) is a medical device company whose goal is to develop a replacement sphincter using transplanted smooth muscle tissue. CMT is an R&D stage company and is currently focused on the development and testing of its device. As an R&D stage company, it has largely pursued a strategy of knowledge exploration in that it has directed its efforts at creating practical knowledge around smooth muscle, implantable device technology, and continence control. At the time of this writing, the company does not have an end product that it can exploit for revenue in the marketplace. However the company was able to strategically exploit its R&D through a 2007 merger with another start-up company, FaecalCare Holdings. CMT merged with FaecalCare in order to exploit a mutual expertise around a related area of continence control R&D.

The founding of CMT itself was a strategic arrangement between a group of researchers at the University of the Southern Hemisphere (known as F5) and their partnership with Gamma Industries. CMT was actually a “clean company” that was created between both parties as a mechanism for the raising of venture capital funding in support of the R&D platform around the replacement sphincter technology. The collaboration between F5 and Gamma started in the late 1990’s. Prior to this collaboration, F5 secured about $1 million in funding from government and private sources so that they could conduct some pilot studies in the area of smooth muscle. F5 subsequently collaborated with Gamma for the purposes of receiving additional funds and complementary technology. F5 and Gamma formally established CMT as a clean company in 2003.

CMT has subsequently received additional funds. Gamma provided an initial investment in CMT when the company was founded in 2003. In 2004, CMT received a $2 million investment from an Australian venture capital firm. As a result of the 2007 merger between CMT and FaecalCare, the investors in FaecalCare provided an additional $1.75 million investment in the merged entity. Additionally, CMT received an AusIndustry R&D start grant for up to $946,000.

CMT is a private company, and FaecalCare is now a wholly-owned subsidiary of CMT. The management structure of CMT consists of a chief executive officer, a chief operating officer, and a chief technology officer. The company and its managers are based in a major Australian metropolitain region that differs from that of the University of the Southern Hemisphere and the other companies in this sample. The company is governed by an eight-member board of directors. It contracts with various researchers at the University of the Southern Hemisphere for much of its R&D. It also contracts with Gamma for the manufacture of its medical devices. It maintains clinical trial sites at private hospitals in two major Australian cities. It also maintains a clinical trial site at a hospital, which is affiliated with another large Australian university. The company is largely a virtual operation, as many of its R&D functions are loosely coupled and distributed among various organizations. Furthermore, the original founding scientists from F5 are mostly uninvolved with the current company.

The current structure of CMT is a function of a shifting epistemological and institutional landscape. The F5 group initially organized as a community of practice within the University of the Southern Hemisphere. Their community eventually extended to include members of Gamma Industries. After F5 and Gamma launched CMT, the company gradually began to shift from a research focused operation to a device development operation, which, in part, reduced the role of the founding scientists. Consequently, CMT is organizationally separate from its founders. The founding scientists' lack of current involvement with the company has decoupled the community of practice from the company, which, organizationally, has left CMT as a virtual entity with mostly loosely coupled participants. Knowledge is created in a distributed manner and organized through the company's management structure. The organization of CMT has largely coincided with the funding that has supported its R&D.

Epistemological factors

In order to understand the organization of CMT and its practices, one must trace the path of the company's R&D. The University of the Southern Hemisphere founders of the company – a group known as F5 – initially organized to pursue the development of a replacement sphincter using the transplant of smooth muscle. Prior to any formal incorporation, the group simply got together with a speculative idea about the possibility of creating a replacement sphincter. The R&D platform has progressed along a path of organization that began informally within the F5 group, which subsequently included formal collaboration with Gamma Industries; then became the R&D platform of the newly established CMT company; and finally became incorporated into a joint R&D program through the merger of CMT and FaecalCare – an arrangement in which only one of the original F5 group members has any current involvement. In essence, the replacement sphincter R&D platform has passed through various hands, ranging from a community of practice within the University of the Southern Hemisphere (F5) to a virtual private company (CMT). This trajectory has captured the knowledge created in steps along the way and has progressively embedded knowledge in each organizational stage.

The origins of CMT date to the early 1990's when F5 had an idea about the use of smooth muscle as a replacement sphincter. There was no existing research on this idea, nor did the F5 group discover any existing intellectual property in the patent literature. F5 subsequently incorporated in order to raise some money for the purposes of doing initial animal tests around their idea. It was a speculative idea at the time, but F5 wanted to push it forward to see if it would work and develop a proof of concept. This type of shared passion for the pursuit of an idea is a characteristic of a community of practice.

> Well there were three of us who had the initial discussions and then we got together with a few people who were interested in pushing the idea and maybe could have helped us to raise some money and we formed a small company

> which was called [F5], which means it had seven people really it sort of meant. Seven of us got together eventually (Respondent #8).

> Well we had an idea, we didn't have any research; we had done no research on the idea. We knew the area but we hadn't actually done any research at that stage. So we formed the company, we raised enough money to do some pilot studies... The first things we did was to patent the work and to… or to patent the idea and then to start some experimental work in animals, rabbits actually, but in animals (Respondent #8).

At the time F5 conducted their initial round of animal tests, the R&D was situated in a lab at the medical school of the University of the Southern Hemisphere. Despite the situating of the R&D in a University of the Southern Hemisphere lab, the boundaries between academic and commercially funded work were relatively clear. Students and post-docs were not involved in any of F5's work. Instead, through the use of their commercial funds, they hired employees to work on their project.

Upon the completion of the initial round of commercially funded tests, which yielded successful results, F5 decided to raise additional funds. The search for this next round of commercial funds led to a collaboration between F5 and Gamma Industries – a large Australian medical device company. From the perspective of F5, the relationship with Gamma was a local source of funds and complementary expertise to support their R&D objectives.

> Gamma is a company that has developed medical devices using implantable electrical stimulation [which we needed] and so they were the obvious company to talk to. We did talk to some companies outside Australia but it was much easier to deal with a company inside the country (Respondent #8).

From the perspective of Gamma, the collaboration with F5 was an opportunity to utilize their expertise in the area of implantable medical devices in a new area of medical device development as an adjacent business opportunity.

> So with the fact that [Gamma] was exploring outside the hearing domain, and had already spent some considerable millions of dollars developing a broad based stimulation platform – that was an asset within [Gamma] – and [F5] came along and said 'we're thinking of something totally leftfield from what', but because we could use that asset, [Gamma] went 'well okay' (Respondent #16).

The collaboration between F5 – a group of university scientists conducting R&D around a replacement sphincter – and Gamma – a large medical device company that primarily served the market on hearing – provided opportunities for novel combinations of knowledge. The collaboration broadened the requisite variety of the R&D project (Weick, 1979; Ashby, 1956) and increased its novelty and complexity (Simonton, 2004).

> You had an entity that knew all about stimulation, you had an entity that knew all about transplantation of smooth muscle and the cellular mechanisms, a little bit about stimulation, not, not huge amounts, and so you were having these two groups come together (Respondent #16).

Organizationally, the collaboration between F5 and Gamma increased the complexity of their R&D project. F5 needed to look beyond their own community of practice in order to find a suitable partner that had the requisite skills, technology, and resources for advancing beyond animal studies. F5 exploited their network of contacts in order to connect with Gamma. Gamma's primary focus was in the area of implantable hearing devices, which required them to structure their collaboration with F5 in a way such that it did not interfere with their core business. The decision was made to organize a "clean company," which would enable F5 and Gamma to raise venture capital funds to support the subsequent rounds of their R&D. Consequently, they organized and founded CMT in 2003. Over an eighteen-month time period, CMT had advanced the R&D project to a stage in which it created a device that it could implant into humans for clinical testing.

With the founding of CMT, the R&D project increased in network scope. Initially, scientists from the F5 group had an agreement in which they would consult for CMT. A general manager from Gamma, who was involved in the initial discussions between Gamma and F5, became the CEO of CMT. CMT contracted with various research groups at the University of the Southern Hemisphere, including the departments of anatomy, cell biology, and veterinary science. As the R&D advanced, tensions arose between the Gamma and F5 groups in the wake of shortcomings with the implantable devices that CMT was developing. Ultimately, all but one of the F5 scientists resigned their consulting agreements with CMT. Gradually, CMT has expanded its network of expertise to include researchers at various Australian universities and affiliated hospitals that serve the company as clinical trial sites. Currently, CMT continues to contract with University of the Southern Hemisphere scientists because of the university's critical mass of relevant expertise. Additionally, the company maintains a supply contract with Gamma, which manufacturers and sterilises the devices. In 2007, CMT merged with FaecalCare Holdings, another start-up company whose continence control technology in the area of faecal management complemented the technology of CMT.

In summary, the CMT R&D project has evolved from its conception as an idea within a community of University of the Southern Hemisphere scientists. Its organizational structure has transformed to reflect the evolving nature of the project. The role of the founding university scientists has diminished over time, which reflects both the evolution of the R&D as well as disagreements among the parties involved in the project. At present, CMT is largely a virtual company, which reflects the distributed nature of the requisite expertise desired by the company as well as the clinical trial stage of the R&D. The CMT project has remained a relatively open social structure, as evidenced by the expanding connections between the project and experts from other various organizations who contribute to it.

Institutional factors

Since its inception, the R&D project underlying CMT has been commercially supported. As such, it has largely adhered to a commercial logic. Despite the participation of university labs and university scientists throughout the various stages of its R&D, the CMT project has not been characterized as an academic undertaking.

Furthermore, the relative lack of university support in the commercialization process has influenced the social structure of the project and the nature of collaboration among parties to it.

Neither F5 nor CMT has symbolically sought to legitimize their activities through traditional academic channels. With the exception of specific research ties between CMT and the University of the Southern Hemisphere, the company is largely guarded from the rest of the academic community. At the direction of the company CEO, very little academic material related to the CMT R&D project has been published. This decision was made in order to protect the company's intellectual property position. Additionally, no studies from the F5 group related to CMT have been published. These qualities beg the question of whether or not CMT has strategically sought academic legitimacy. Through the extended network of the R&D collaborators at the University of the Southern Hemisphere, other universities, and Gamma, multiple scientific collaborators have been exposed to the knowledge base underlying CMT. The passage of knowledge through these channels suggests a modicum of the project's credibility. Yet the lack of open dissemination in the form of presentations and publications leaves the company with a lack of symbolic academic legitimacy. Additionally, the lack of technology transfer office involvement in the venture has left the company without a university-level champion. Overall, the lack of academic transparency suggests that academic legitimacy has not been a strategic priority for CMT.

In contrast, the company has sought and has achieved multiple instances of commercial legitimacy. Multiple rounds of investor funding are indicative of investor confidence in the underlying idea behind the CMT project. The F5 group successfully raised an initial round of funding from both private investors and government funders, and they subsequently secured the interest and financial support of Gamma Industries. Once formally established, CMT received additional venture capital funding in 2004. In 2007, CMT was merged with FaecalCare, and the combined company received additional funding.

Intellectual property protections further symbolize the company's commercial legitimacy and assure investors of the strength of the company's knowledge assets. Furthermore, the protection of intellectual property has been prioritised ahead of any forms of symbolizing academic credibility. It is evident that the impact of academic legitimacy is something that company officials have considered, but they have nevertheless decided to keep their R&D project relatively non-transparent beyond participants.

> There's been, we've had very limited publications because… I wanted us to be able to hit the airwaves with something strong, and I wanted to make sure we didn't complicate our intellectual property position by drawing attention to ourselves prematurely… So there was a couple of… publications and we have some stuff that, that is going into publication at the moment. But no I, I intentionally kept it pretty low (Respondent #16).

As such, close to a decade and a half of academic research has not been publicly disseminated at the desire to protect the commercial integrity of the company (see Gumport, 2000).

The intellectual property of CMT is protected by one identified patent, and the company has several patents pending to further protect its IP. Just as academic conference presentations and publications symbolize academic legitimacy, patents symbolize the commercial legitimacy of a new company (Higgins and Gulati, 2003). The company's limited patent portfolio, coupled with the developmental nature of its medical technology, likely limits any academic knowledge dissemination because such knowledge would not otherwise have a sufficient level of IP protections behind it. Without widespread academic dissemination, the company has not constructed an academic narrative of the knowledge that underlies the company's developments, nor has a visible company champion emerged.

The University of the Southern Hemisphere was mostly non-involved in the commercialization of CMT. In the mid 1990's when F5 decided to seek commercial funds in support of the ideas within their community of practice, they were responsible for bearing the costs associated with any intellectual property protections or commercial development. It was a difficult process for the F5 group to individually undertake (see Wright, Lockett, Clarysse, and Binks, 2006). Despite F5's responsibility for bearing the patent costs, the University of the Southern Hemisphere remains a beneficiary of the CMT patent.

> I don't know where he [university vice-chancellor] got the advice but it certainly wasn't from anybody in the university, that IP should be put in the hands of the university inventors, that they should be responsible for paying for the patent cost and that didn't work quite obviously because most of them don't have the

money to pay for the costing. So with F5 and CMT, we've probably spent maybe three or $400,000 on patenting and licensing and protecting inventions and very few academics have three or $400,000 that they could spend on that sort of work. So it was… not to put too fine a point on it, it was a disaster (Respondent #8).

Currently, the company has an investment tie to the university. The company maintains some contact with University Enterprises in the context of shared intellectual property.

In summary, the combination of institutional factors – the university's lack of involvement in commercialization; the partnership with Gamma; the founding of CMT; and the merger with FaecalCare – has shaped the social structure of the underlying R&D project to create a replacement sphincter. The ongoing need to raise multiple rounds of money in order to support the evolution of the R&D has been a factor in shaping the project's current virtual structure. Virtual companies require little overhead, which frees capital to be spent on an otherwise exploratory project and on its core R&D operations. The current lack of involvement by the founding scientists has decoupled the community from the project, which has resulted in a loosely coupled structure of scientists who are coordinated by a small management team.

Creating knowledge

The evolving social structure of the replacement sphincter R&D project is indicative of knowledge creation and transfer in the context of CMT. As a largely virtual company, the management team has the responsibility of coordinating the various project contributors and the knowledge generated by them. As a venture whose R&D has evolved over the course of a decade and a half, knowledge has been codified and transferred among numerous participants. The initial years of the F5 community of practice would have offered many opportunities for “bench level collaboration” (Zucker, Darby, and Armstrong, 2002) and the articulation of shared meaning.

Crossan, Lane, and White (1999) describe a challenge that innovators often face with respect to knowledge. They write, “True innovators have a problem akin to the child (trying to describe something for which it has no words to do so). They have a sensation – an insight into a possibility – but they have no literal language to describe it” (p. 527). F5 faced a similar situation. They initially speculated about the possibility of using transplanted smooth muscle in the development of a replacement sphincter, but they had nothing more than their vision from which to build. They organized in order to build upon their idea. In doing so, other participants gradually joined them in constructing knowledge and insight around their idea. A very practical need – creating a device to treat human incontinence – motivated F5 to organize, assimilate existing knowledge, and to create knowledge (Popper, 1972). The subsequent knowledge that F5, Gamma, CMT, and FaecalCare has created has been directed toward this practical end and constructed to the norms and practices of developing a medical device through commercial channels (Knorr-Cetina, 1981). Very little knowledge has been publicly disseminated from this R&D project. Consequently, “knowledge transfer” has been largely confined to the social structure of the project.

> And so to get a, to gain that sort of knowledge where it is cutting across function, things like the work we did certainly fostered that, that transfer of knowledge in that sense albeit was within the tent of confidentiality and control of [CMT] (Respondent #16).

Finally, the evolution of the CMT R&D project reflects a desire to increasingly create order from disorder. The project began with a speculative idea, and it evolved into a speculative company. The roles of the F5 founders have diminished over time, and they experienced disagreements with their collaborators at Gamma. Multiple partner scientists from various organizations have increasingly filled project roles. The CMT management has faced the task of coordinating these various actors as well as assimilating their knowledge and transferring it throughout the project's evolving social structure. Knowledge is created through organization and the order that can be achieved from an R&D project such as the replacement sphincter project of CMT (see Patriotta, 2003).

Discussion and conclusion

This chapter describes academic spin-off companies that might not resemble the types of "companies" that one is accustomed to envisioning. In many ways, Delta and CMT represent a profound shift in the nature of innovation and knowledge creation. The idea that a "company" can exist as a globally dispersed network of experts whose collaboration is facilitated in part by modern information technologies and orchestrated by a small management team differs significantly from traditional notions of established firms in distinct locales. CMT and Delta are organized as exploratory R&D projects that assemble clusters of diverse university and non-university experts and research teams to contribute to project efforts. The incorporation of each of these as companies provides coordinating mechanisms in the form of investment capital and management teams who assemble and integrate these networks of knowledge and expertise. As R&D projects, commercialization is a means to an end in that commercial funds are used to fund a major project that might pay off in the long term but is generally not capable of earning any significant revenue in the short term.

In some ways, the role of the university shifted to the background of these two companies. Delta and CMT both emerged from the activities of University of the Southern Hemisphere research teams, and some of the early commercially funded work occurred at the founders' University of the Southern Hemisphere labs. University scientists and their labs continue to fulfil some – but not all – of the needs for each company. In the case of Delta and CMT, these founders play an increasingly limited role over time as their respective projects advanced through developmental phases. Consequently, the University of the Southern Hemisphere became less institutionally critical for each company's practices, as the management structure of each respective company assembles knowledge resources from other various universities and other organizations. Because of the shifting role of the University of the Southern Hemisphere as well as the lessening of overall academic influence in each of these companies, these cases suggest that an "academic spin-off company" may become less "academic" over time.

As with any new venture, the companies in this chapter illustrate the dynamic of legitimacy and the ways in which a company achieves legitimacy. Both companies amassed venture capital funding and patent protections, which symbolize their commercial legitimacy. Both companies are based on academic science, but the notion of academic legitimacy was a point of departure between them. Delta is a relatively transparent company whose knowledge base has been disseminated through traditional academic channels, which has added credibility to the company's R&D project and was important for signalling its promising aspects. Establishing and updating academic legitimacy has been critical for Delta because one of its investors did not fully accept the strength of the findings from some initial studies. In contrast, CMT is not very transparent in that it has not openly disseminated its research findings. The founding group of scientists established credibility with a major corporate collaborator based on their idea and the work they ultimately conducted in partnership. Yet the need to continuously subject CMT R&D to academic peer review has not been strategically critical for the company. The differing notions of academic legitimacy impact the company's relationship with the academic community and illustrate each company's degree of transparency as an academic entity.

Coordination of a virtual company suggests that knowledge is captured and transferred through the coordinating roles of company managers. The virtual nature of these companies reflects many years of coordinating and codifying knowledge across a network of partners. The cases illustrate ways in which each company is an organizing mechanism through which knowledge can be assembled, codified, internally transferred, and externally disseminated. Each company's respective projects are goals that articulate the knowledge and expertise requirements, and the company structure is a mechanism for achieving order. Each company has created knowledge, as evidenced by their ability to advance among R&D and clinical trial stages. Each stage represents accumulated learning and insight. Some of this knowledge has been disseminated through academic conference and publication channels, as determined by each company's strategies and tactics for signalling legitimacy.

In summary, this chapter has illustrated two academic spin-off companies that are organized as virtual companies for the purposes of assembling a wide network of experts who contribute to long-term R&D projects. The coordination of these networks of loosely coupled experts enables knowledge creation by bringing order to these collaborative relationships and through the assimilation and transfer of collective learnings. The "founding" universities from which project emerge matter to these companies, but their roles evolve throughout the evolution of R&D projects. Companies can assimilate scientists and experts from other universities and from other non-academic organizations into the rhythm of each project, therefore minimizing the role that any one university plays in the context of each project. In some cases, university scientists play relatively few roles in the advanced developmental stages of these projects, which can further lessen academic institutional influences on these ventures. Academic spin-off companies that evolve into virtual company structures reflect the richness of knowledge creation. Knowledge creation is increasingly a function of inter-institutional collaboration and collaboration among a variety of parties within the global academic community, and the role of any one university can lessen in the course of an academic venture.

Chapter 6 – Academic Spin-off Companies as Communities of Practice

Introduction

This chapter presents two companies – Alpha Pharmaceuticals and Foxtrot Pharmaceuticals – whose social structures most closely resemble that of an archetypical *community of practice,* with close collaboration among core members as well as ambiguous organizational boundaries. Unlike virtual companies, many of the scientists who work for the companies presented in this chapter do so in close proximity to one another. Yet in a manner that resembles that of virtual companies, Alpha and Foxtrot are organized as long-term R&D projects. Both companies presented in this chapter are "academic" in that the founding university scientists remain involved in much of the company R&D, and many of those activities are conducted in university labs. Consequently, these companies blur the boundaries between academic and corporate activities, as much of the knowledge creation resembles casual notions of academic science.

Both Alpha and Foxtrot are drug development companies. Alpha is organized around the development of drug treatments for neurodegenerative diseases. Foxtrot is organized around the development of a drug treatment of fibrosis. In both cases, the company founders pursued commercialization because their intellectual property was valuable enough to secure the investment dollars of venture capital firms. The money that both companies raised supports their extensive R&D programs that are aimed at bringing their respective drugs to market. Alpha has also raised additional money through an initial public offering of stock. Both companies are speculative in nature in that their projects are aimed at the long-term creation of knowledge that ultimately supports their R&D. As such, they have not yet turned a profit for their investors, and they have relatively little intellectual property to exploit in the short term for revenue in the marketplace. Alpha was established over a decade ago, and has actively disseminated research findings related to its R&D and underlying knowledge base in an effort to signal its academic and scientific credibility and legitimize itself as an enterprise. Foxtrot was established in 2007 and has not yet engaged in similar dissemination efforts for the purposes of strengthening its legitimacy. However, academic credibility remains an important factor for the company. Both companies maintain idiosyncratic relations with the University of the Southern Hemisphere. University Enterprises actively helped commercialize Foxtrot, while no university technology transfer channels were involved in Alpha's commercialization efforts. However, both companies maintain extensive R&D ties to the University of the Southern Hemisphere and with other universities.

Alpha Pharmaceuticals

Goals and strategies

Alpha is a drug development company that is organized to conduct R&D on neurodegenerative diseases – especially Alzheimer's and Parkinson's diseases – and develop drug treatments. The company has adopted a strategy of exploration (March, 1991) in that it is an R&D company focusing on the long-term development of drug treatments. The company is currently engaged in clinical trials of an Alzheimer's treatment, but it does not currently have a drug on the market and therefore is not yet earning product revenue nor exploiting its intellectual property. Alpha leverages its ties to the academic community to signal the credibility of its knowledge base and R&D program, which enables the company to generate additional funding from investors. It is a publicly traded company.

Alpha is a small company. As of June 30, 2008, the company had a total of 13 employees. Eight of those employees were in R&D, three of those employees were in management and administration, and two were in operations. Consultants fulfill other important roles at Alpha. Scientific co-founders Elwood Feagley and Marlin Guitierez are consultants to the company and have served on the company's scientific advisory board. Marlin Guitierez continues to work from an American Ivy League University (ILU). Elwood Feagley returned to Australia from ILU in 2005 and is now primarily based at a local mental health research facility, which is located near the University of the Southern Hemisphere campus.

The company has a solid presence in the local area, but it also has an extended worldwide network of collaborators. Each of the company employees is locally based. Much of the company's day-to-day R&D work is conducted at the University of the Southern Hemisphere or at the mental health facility. The local concentration of R&D enables key company scientists to interact as a community. In the beginning years of the company, some of the critical R&D work was conducted at Ivy League University. However, none of the current R&D associated with Alpha's latest drug compounds is conducted at ILU. Alpha has a history of collaborations with universities and research institutions locally and worldwide. For example, the different stages of its clinical trials were conducted at a variety of locations, including Boston, London, and Uppsala (Sweden), which incorporated other experts into the company's extended network of practice.

Unlike other companies in my sample whose virtual structures reflect loosely coupled scientific collaborators, Alpha's structure reflects a strategic decision to align its R&D program with the academic community and its local knowledge base. Since 2005, Alpha's key scientific collaborators have been located in close proximity to one another and have been part of the region's local concentration of mental health research experts. This concentration has provided the company with access to key knowledge resources that has supported its R&D program, which has consequently impacted the company's social structure. Alpha's R&D program is rooted in an area of Alzheimer's research, which at one point in time deviated from accepted theories about the cause of the disease. Consequently, Alpha has actively pursued the strengthening of the company's legitimacy through the open dissemination of its research findings. The combination of knowledge dissemination and public company are key institutional factors that impact the company's structure and transparency.

Epistemological factors

The discovery of a cure for Alzheimer's disease has eluded scientists for many years. One of the reasons for these difficulties lies in the uncertainties about the disease's cause. Alpha is rooted in a line of research that theorizes about the cause of the disease. The work focuses on the amyloid precursor protein (APP) as the gene associated with the disease. The APP gene demonstrates metal-binding sequences, which suggests that metal toxicity in the brain – caused by the binding of naturally occurring brain metals with APP to form plaques – is a cause of the disease. The APP research of Elwood Feagley and Marlin Guitierez at Ivy League University in the 1990's is the basis of the founding of Alpha and its subsequent R&D efforts. Their Alzheimer's research differed from conventional theories about the cause of the disease, which necessitated the raising of money to support their ongoing efforts.

> But sure enough, it [APP research] got into [the journal] *Science,* and it basically generated a whole cottage industry now of hundreds of papers that look at the method of how metals drive the amyloid toxicity and this has become the main target and platform of Alpha (Respondent #17).

The knowledge base underlying Alpha's Alzheimer's R&D efforts reflects revolutionary aspects of science as described by Kuhn (1970). Much research has been conducted around Alzheimer's disease, which has led to the creation of much knowledge and paradigmatic beliefs about aspects of the disease. Yet the lack of certainty about the disease's underlying cause leaves an opening for revolutionary ideas to challenge existing paradigms and update existing knowledge in an effort to ultimately solve the practical medical challenges posed by the disease. The organization of Alpha reflects the continuously evolving nature of their R&D efforts to develop their theories around APP and a drug treatment that counteracts metal toxicity in the brain, but it also reflects the company's efforts to revolutionize the study of the disease.

In the early 1990's, Marlin Guitierez and Elwood Feagley worked together in a lab at Ivy League University. Feagley, who was from Australia, was working for Guitierez as a postdoctoral researcher. A company called Midwest Pharmaceuticals (pseudonym) was funding Guitierez's amyloid research and, in essence, was funding Guitierez's fellowship. Eventually Midwest Pharmaceuticals stopped funding this lab because of its changing interest with respect to amyloid research as well as its overall need to control costs. The Midwest Pharmaceuticals funding roughly lasted from 1993-1997. By 1997, there was an interest in forming a company as a way to raise money for the continuation of this line of research, which was believed to have long-term commercial potential in that it showed promise as a line of sight toward the development of an Alzheimer's treatment. Elwood Feagley arranged private funding through a long-time friend in Australia who was able to attract another investor. Thus, Alpha was established as a company in 1997. It was incorporated in Australia, but much of the initial R&D work occurred in the United States at ILU from 1997 until 2000.

Alpha is organized as a community of practice, which reflects the close working relationship among a core group of scientists on a specific R&D project. The locus of this community has shifted since the company's founding. When the company was originally founded in 1997, much of the company's R&D was based in labs that were affiliated with Marlin Guitierez and Elwood Feagley at ILU in the United States. Initially, Feagley worked in Guitierez's lab, but Feagley started his own lab upon completion of his post-doctoral training. Elwood Feagley maintained ties to his former University of the Southern Hemisphere PhD advisor, Rod Pfrogner, while he was based at ILU, and he involved Pfrogner in some of the company's initial R&D work. Thus, the initial Alpha community consisted of scientists working in both Boston and Australia. Interestingly, Guitierez and Feagley were treating transgenic Alzheimer's mice with specific drugs and sending the mice brains to Rod Pfrogner in Australia for his analysis. Despite the physical distance, these three scientists had established a work rhythm (see Bauer, 2007) that was generating insight and knowledge – as research findings were being transferred within their community of practice. By 2000, Alpha had developed a prototype drug, and it subsequently became a publicly-traded company in order to raise for continued R&D and subsequent clinical trials. At that time, much of the company's R&D had shifted to Rod Pfrogner's lab at the University of the Southern Hemisphere. Elwood Feagley left the United States and returned to Australia in 2005.

The locus of Alpha's community of practice is currently in Australia. Rod Pfrogner and Elwood Feagley maintain labs at the University of the Southern Hemisphere and the mental health center, respectively. Some of the scientists who work in these respective labs conduct Alpha-related research, which contributes to the local community of experts contributing to Alpha's R&D program. The University of the Southern Hemisphere is engaged in ongoing work related to Alpha. Alpha's medicinal chemistry program is based at the university, and much of the company's scientific base since 2000 stems from research conducted at the University of the Southern Hemisphere under the direction of Rod Pfrogner. One respondent articulates the nature of the company's current rhythm of practices.

> [The structure] is very tight... There are two or three key individuals who do the research work, who meet regularly to define the direction of the research in collaboration with the company officers. They determine how the work is going to be done and what needs to be done. The chemists are producing compounds, which are then going to pre-clinical testing and eventually come out the other end for human testing (Respondent #3).

Alpha's local network of collaborators extends beyond the University of the Southern Hemisphere. In 2003, Alpha joined a local research alliance that consisted of a biotech start-up company engaged in the development of cancer therapeutics, a public health research institute, and the University of the Southern Hemisphere. The commonwealth government provided a $250,000 grant for this project, and it was intended to develop a cure for Alzheimer's disease. Through this collaboration, Alpha was able to access certain vaccine technologies from the other company. However, Alpha terminated its agreement with it in 2006 because of certain delays in reaching specific milestones. Alpha did however continue to collaborate with scientists from the company who eventually left the company and subsequently moved to another local university. Alpha also formed a collaboration in 2004 with a subsidiary of this other company and the University of the Southern Hemisphere in the development of an Alzheimer's disease vaccine. In general, Alpha's embeddedness in the knowledge network and social structure of the region near the University of the Southern Hemisphere has been a beneficial asset of fostering a community. As one respondent noted:

> Yeah, it's very easy to meet with people that's for sure, because we're here in a sort of, in the park for precinct which means Alpha is five minutes drive in that direction. University is five minutes drive in that direction and when you want to have meetings with larger groups of people, it's very easy to get together and that does make a difference. So that kind of simple infrastructure makes a lot of difference (Respondent #4).

Despite its local knowledge base, Alpha's network globally extends to include numerous collaborators, especially with respect to the company's clinical trials and related research efforts. London and Uppsala (Sweden) were two international clinical trial sites that involved collaboration with scientists at those sites. Clinical trial sites are determined based upon specific expertise that is needed to conduct a trial with a given sample population, which necessitates the location of trials in a variety of locations. The company also has a tie to an American west coast research university. In 2005, Alpha established ties with researchers at this university's department of neurology and, concurrently, with the affiliated Veteran Affairs Medical Center. Alpha was involved in a study of Huntington's disease. The study produced findings that suggested a promising line of research that the company conducted in collaboration with this university's researchers. The nature of these global collaborations is rooted in the company's attitude toward the global nature of academic science. As one respondent noted, Alpha is part of an extended community of scientists.

> Scientists know who's doing what, so we're a community of people who know who's doing what… I can give you an example. We want to study some aspect of illusion in the retina, right? We don't do that ourselves, so we look around Australia, and then we look around the world – who's doing that work? Then, because we happen to know somebody who knows somebody who does that specific work in London, we just pick up a phone and talk to that person in London and say, 'Hey, we've got a drug here, we want you to test it on the eye. Would you do it?' And they say, 'Yup,' so research contracts draw it up and the work's done and you get the result (Respondent #3).

Alpha also continues to maintain a close connection to Ivy League University. In its annual reports, Alpha lists ILU as a "core research alliance" and notes that ILU was a source of some of the company’s core intellectual property. Alpha formalized certain aspects of its tie with ILU. In 2001, the company signed a three-part agreement with ILU. First, Alpha would pay for a portion of Elwood Feagley’s research that would ultimately feed into Alpha’s knowledge base. Second, the chief of psychiatry at ILU would consult with Alpha in the areas of clinical trials and regulatory matters relating to the FDA. Finally, ILU would provide Alpha with an exclusive license to a patent application relating to a dopamine agonist in the therapeutic treatment of Parkinson’s disease.

The organization of Alpha reflects over a decade’s worth of collaborations between a core community of scientists and multiple experts around the world in the context of a specific R&D program to develop a treatment for Alzheimer’s disease. The connectedness of the company reflects the intellectual diversity that has contributed to this program. Although the company’s current core activity is the development of a drug treatment for Alzheimer’s disease, its extended network of collaborations have reflected a strategic interest in broadening the company’s knowledge base in the area of neurodegenerative diseases. These collaborations contribute to a broad knowledge base that ultimately enriches the expertise that is engaging in the core Alzheimer’s drug development project. Thus, its strategy of knowledge exploration is broad-based and reflects a deliberate effort to position itself at an axis of neurodegenerative research.

The boundaries between academic and commercial science are blurred in Alpha’s social structure. Elwood Feagley, Marlin Guitierez, and Rod Pfrogner are key members of the company’s scientific team, but each member holds primary academic appointments with universities and academic research institutes. The work that they formally do for Alpha does not constitute their full time schedules, yet much of their work ultimately contributes to the company's knowledge base. This is consistent with the nature of communities of practice (see Wenger and Snyder, 2001; Wenger, 2000). In communities of practice, members often work together while maintaining separate roles in other formal organizations. Despite the evolution of their roles within the Alpha social space, these three scientists sustain a level of commitment to the company because it represents a long-term project that is fuelled by their research interests.

Institutional factors

A variety of institutional factors drive Alpha's organizational structure. The publicly traded nature of the company represents the highly systemized nature of the company's legitimacy in the commercial marketplace. The ongoing dissemination of research findings related to the company's R&D represents the company's legitimacy within the academic community. As a function of its corporate legitimacy, much of its knowledge base is protected as intellectual property through the patent system. However, as a function of its academic legitimacy, academic peers have gradually accepted Alpha's knowledge base as credible by way of the traditional dissemination channels of publications and conference presentations. Consequently, Alpha is fairly transparent. One of its key scientists has evolved as one of the company's major multi-institutional advocates and has played an integral role in shaping the company's narrative of its mission, its knowledge base, and its overall R&D strategy.

The company's successful fundraising symbolizes its legitimacy as an R&D stage company. In addition to its 2000 initial public offering of stock, which symbolized the market's willingness to accept some risk around the company's R&D platform, Alpha has received numerous sizable grants. It received a $1.74 million START grant from the Australian Industry Research and Development Board with subsequent follow-up funding of $1.35 million. It received a $230,000 Ausindustry grant and a $250,000 Commonwealth government grant in collaboration with another biotech company. To date, the company has also raised close to $100 million in additional private funding.

Alpha's intellectual property portfolio is also symbolic of its legitimacy (see Higgins and Gulati, 2003). As of the date of the filing of Alpha's latest annual report, the company has 22 patents and patent applications in its portfolio. It also has a library of over 400 drug compounds, each of which represents a potential drug development project. It is from this library that the company has selected its most promising compounds for clinical trials. The library of compounds specifically gave Alpha the flexibility to shift its R&D efforts from one lead compound (C1) to another (C2) in 2005 when C1 demonstrated impurity issues. Colloquially, the company didn't miss a beat in that its library of compounds provided it with a back-up, which it could enroll in new clinical trials while maintaining the overall credibility of the R&D program. A robust intellectual property portfolio also protects the company as it disseminates its research findings. Strategically, Alpha filed the requisite IP protections behind the dissemination of findings. As one respondent notes, this is a typical strategy for drug development companies like Alpha, and it balances the importance of protecting IP with the desire to publish. IP protections are a prerequisite for academic transparency.

> If you're planning on doing IP, you generally file it before you submit the paper or before you present it. But then you – if you're in a company, the company might say, 'We're not going to publish the paper until the IP publishes.' In academia, no, in academia you just file the IP, you get the protection but you don't care about keeping it a secret, so you put the paper out whenever you want. [In a company] you just file the IP beforehand if you want to protect that (Respondent #17).

Academic legitimacy has been a strategic priority for Alpha since it was founded. This stems from the knowledge base of its R&D platform in that it was a radical departure from conventional knowledge about the underlying cause of the disease. The novelty of the knowledge base, in part, drove the efforts to commercialize as a new company. Traditional scientific funding agencies (i.e. government funding agencies such as the NIH) were skeptical of the ideas, which led to the seeking of investors who were willing to take a risk on their approach.

> Even to this day, no-one knows what the cause is so there's no treatment currently that is guaranteed to work that's a biological disease modifying treatment for Alzheimer's disease, we're still not at that point. In 1996 we knew much less, yet there's as much bombast now as there was then and there was huge amount of bombast then, people simply thought they knew, they knew

> what it was going to be, they knew what it would take to fix, well nonsense. So therefore, someone like me came along with good scientific credentials and good publications but a theory that was not very familiar, it was impossible, it was just ridiculous, so that's what motivated me to go out into the commercial world (Respondent #4).

The establishment of academic credibility has been integral mechanism for Alpha's organization. As a company that was established as a mechanism for the raising of money and the exploration of new knowledge, Alpha emerged with a liability of newness (Hannan and Freeman, 1977; Stinchcombe, 1965) on multiple levels. First, as a drug development company, Alpha entered the commercial marketplace from a speculative position. Second, the knowledge base that underlined its R&D program was radically different from existing theories about Alzheimer's disease. Therefore, the company was both commercially and academically speculative, which necessitated efforts to overcome both constraints. The company settled into a rhythm in which managerial practices of fundraising and IP protections coincided with a steady stream of academic activities that disseminated research findings and strengthened the company's R&D position through the peer review process.

> I think there's usually a need to publish. Companies usually just publish and present to raise money and to raise value. Depending on how much you need to do that, that's how much you present and publish rather as opposed to keep secret... Biotech company start ups don't have a clinical pipeline, they can only

> raise money on the promise of their pre-clinical discovery and development. So they have to tell stories, they have to get out there and publish and present to raise interest in the company and raise money. So I think it's that simple (Respondent #17).

The championing of the company integrated into the rhythm of Alpha's organization. One benefit of Alpha's community of practice structure, which maintained connections among a core group of scientists for an extended period of time, was the long-term growth of the company's advocacy and the subsequent construction of a consistent narrative about the company, its mission, and its work. Alpha was one of the companies in my sample that benefited from having a clearly defined *champion* who could speak with credibility and enthusiasm to multi-institutional audiences about the company's scientific capabilities in an effort to raise the company's legitimacy in order to sustain the support of stakeholders. A champion would do what one venture capital professional described as:

> "[Communicating] the impact of their research in a relatively intelligible manner to those who are not skilled in the art" (Respondent #9).

Alpha's founding team of Marlin Guitierez, Elwood Feagley, and Rod Pfrogner had strong CV's and had developed a track record of academic achievements. The collective academic abilities of these scientists helped legitimise the company (Tornikoski and Newbert, 2007).

Elwood Feagley evolved into the role of the company champion, as the individual who acted as the public face of the company's collective academic productivity and legitimacy. He acted in this role while participating in "investor road shows" with the company's CEO. Feagley's role at an investor road show would consist of presentations that would mix academic rigor with an enthusiastic pitch for the company's scientific potential.

> We've spoken to hedge funds over the years, the notorious hedge funds and of course institutional investors and big pharma. So you go in basically with the objective to try and enthuse the other side to invest one way or the other. So it's absolutely necessary… At conferences it's all about scientific rigor and on road shows it's a combination of rigor and trying to gather enthusiasm (Respondent #4).

Over time, this strategy resulted in a refined narrative about the company. Such a role is consistent with sensegiving strategies (Holt and Macpherson, 2010; Maitlis and Lawrence, 2007; Hill and Levenhagen, 1995).

The internal championing of the company was especially important for Alpha because it was not "spun off" through any formal university technology transfer channels. No TTO championed the company during its critical early commercialization stage. The company's successful raising of commercial funds and entrance into the commercial space stemmed from direct personal relationships between scientists and investors (Knockaert, Wright, Clarysse, and Lockett, 2009). Both the University of the Southern Hemisphere and ILU were licensors of Alpha intellectual property. One of the early roles of the company managers was the securing of IP from the university and ILU, and Alpha continues to maintain a series of intellectual property agreements with both parties. Consequently, the championing of Alpha was largely an internal process that was separate from university involvement.

Creating knowledge

Alpha's R&D program is based on a line of Alzheimer's research that, at one point in time, differed from conventional theories about the cause of the disease. Collins (1989) argues that the divergent factions between scientific paradigms create an intellectual tension, and the resolutions around which symbolize the creation of new knowledge. In essence, Alpha has created new knowledge about the underlying cause of Alzheimer's disease. The company's increasing academic and commercial legitimacy reflects this knowledge. The evolving stages of clinical trials of the company's key drug compound manifest and reflect an accumulation of new knowledge.

Knowledge creation at Alpha adheres to a constructivist perspective (Knorr-Cetina, 1981). The company's R&D platform is a function of the desire to solve a practical medical need for the treatment of Alzheimer's disease. However the R&D that has produced new knowledge has been subject to the inter-institutional constraints of funding and skepticism against the novelty of the platform. Alpha has successfully legitimized its R&D platform as evidenced by the ongoing funding that it has received as well as the multiple peer-reviewed publications and academic presentations that have symbolized its credibility. In essence, Alpha has created knowledge that seeks to minimize any skepticism against it, thus moving the company closer to solving its mission-driven medical challenge.

Practically speaking, the current phase of Alpha's clinical trials reflects close to a decade and a half of R&D. Some of this R&D involved the creation of over 400 compounds – each of which has the potential to serve as the basis for a drug treatment. This library of compounds reflects years of insight around what works and what doesn't work. When the company's C1 compound faced impurity issues in the clinical trial process, the subsequent shift to C2 as the lead compound is indicative of a granular richness of knowledge that had been integrated into company learning patterns. In other words, the switching of lead compounds would not have been possible if knowledge about the compounds and their potential was absent. These compounds have the potential to be developed into possible treatments for other neurodegenerative diseases such as Parkinson's disease and Huntington's disease, and they have also attracted the interest of researchers in the areas of oncology and cardiovascular disease. This library of compounds has generated traction among other researchers, which further indicates Alpha's accumulated knowledge and the credibility associated with it.

The local situating of much of Alpha's community of practice as well as the global reach of its extended collaborative network has other interesting implications for the creation of knowledge. Despite a local concentration of Alpha R&D, the primary scientists also maintain respective networks with other scientists and experts from around the world. As a result of these networks and the structural holes that bridge them to a variety of expertise (Burt, 1992), the company is able to utilize the expertise of these experts for various research tasks as needed. In essence, the company creates knowledge on a local level through a rhythm of close interaction, and it accesses knowledge through its extended network on a global level. Locally, the company's community of practice facilitates social personal interaction, which generates tacit knowledge. Globally, the company's extended network of practice generates codified research results that are subsequently internalised into the company's knowledge base (Nonaka and Takeuchi, 1995).

Foxtrot Pharmaceuticals

Goals and strategies

Foxtrot Pharmaceuticals is an early stage drug development company whose goal is the development of a drug for the treatment of fibrosis that occurs in such chronic diseases as kidney disease, heart failure, pulmonary fibrosis, and arthritis. Strategically, Foxtrot is an exploratory company (March, 1991), as it is engaged in pre-clinical-trial phase R&D. The company was founded as a vehicle for the raising of commercial funds to support the R&D project of its fibrosis drug treatment. Foxtrot is a small private company whose funding has been provided by grants and venture capital investment. Prior to the receipt of venture capital funds, the company's R&D was largely tied to discretionary funds associated with the research budgets of some of the company's founding scientists.

The securing of its primary intellectual property was strategically critical for the launching of Foxtrot as a business venture in 2007, as the basis of the company was the development of an existing off-patent drug that demonstrated anti-fibrotic qualities. Because the scientific development involved the use of an off-patent drug, it was important for the company to secure new composition-of-matter patents for their work. The composition-of-matter patent gives the company a strong intellectual property position because it represents novel attributes and improvements to the off-patent drug. In contrast, a method-of-use patent on an existing drug would not have provided the company with an adequately strong intellectual property position to meet the satisfaction of its eventual investors. Chemical compounds comprise the bulk of Foxtrot's intellectual property portfolio. Currently, Foxtrot has a library of 50 chemical compounds, one of which is a lead compound that is positioned to proceed through the clinical trial process.

Foxtrot is organized as a community of practice around a specific drug development project. Most of its scientists work in close proximity to one another, and each have academic responsibilities beyond their respective roles as members of Foxtrot's drug development project. Many run their own labs. The company's founding team consists of several university scientists – each of whom is employed by their respective academic units. Tim Holford is a chemist who runs an organic chemistry lab at the University of the Southern Hemisphere and works with a post-doc who has created the company's molecules. Maurice Gillock is a senior research fellow at the University of the Southern Hemisphere who runs a lab in the area of biochemistry and molecular biology. Jerold Carlsten – who serves as the company's CEO – is a medical researcher who works at a local hospital, which is affiliated with the University of the Southern Hemisphere's department of medicine. Two of Jerold's previous collaborators also work with Foxtrot as scientific advisors. One is a clinical endocrinologist at a Canadian University and a former professor at the University of the Southern Hemisphere. The other is the head of clinical pharmacology at another Australian university and has experience in the design of clinical trials.

Because of its early stage nature, Foxtrot has been relatively guarded from disseminating any research findings associated with its R&D. Consequently, it has not sought widespread academic credibility as a strategic factor. Despite any widespread dissemination of knowledge beyond the company organization, Foxtrot's closely-knit and interdisciplinary community of practice of core scientists has yielded novel insight and new knowledge that has been instrumental in the company's R&D.

Epistemological factors

Interdisciplinary collaboration has been a cornerstone of Foxtrot's R&D and commercialization efforts. The company's drug development project is a collaborative effort among scientists from chemistry, biochemistry, and medicine, and the project incorporates both research and clinical experience. Furthermore, the company exemplifies the University of the Southern Hemisphere's deliberate recent efforts to spark interdisciplinary collaboration among scientists through co-location of labs. The co-location of scientists in a new university research facility – known as Veritas – was responsible for the meeting of individuals who would eventually collaborate and help launch Foxtrot.

Initially, Jerold Carlsten was working to increase the potency of an off-patent drug that demonstrated anti-fibrotic qualities. He contacted Maurice Gillock, who had recently relocated to Veritas and who had recently met Tim Holford at Veritas. Gillock introduced Holford (a chemist) to Carlsten in order for Holford to help Carlsten generate some new drug molecules. Holford enlisted his post-doc, Rico Ceconi, in the actual development of the molecules. The novelty in this connection was that chemists are not known for generally collaborating with medical researchers (or vice versa). The connection represented the strength of a weak tie between Holford and Gillock (see Granovetter, 1973). This connection also marked a tipping point because it enabled cross-disciplinary creative abrasion (Leonard and Sensiper, 1998) that was critical for jumpstarting the collaborative research that formed the basis of Foxtrot. One of the company respondents describes the dynamic among Foxtrot's interdisciplinary team.

> [Rico and Tim] are completely different because they're coming from a synthetic approach and not as much knowledge as the cell side of things, and I'm coming from another angle looking at learning how the drugs interact with the cell systems at a micro level. So the ones that [Jerold's] got look at the outside the cell, what's happening, changes to the cell, I look at the inside of the cell and the guys upstairs are marking the things to go around the cells. I think we're quite a good team and then we've got the clinicians that... I mentioned, they're looking at what happens inside the patient (Respondent #6).

Foxtrot's intellectual diversity is representative of the various stages of the company's R&D, including the creation of molecules, the testing of molecules in animals, and the clinical aspects of human testing. The deliberate combination of scientists from different disciplinary backgrounds within the context of Foxtrot's R&D is consistent with Simonton's (2004) argument that breakthrough science stems from actions of scientists who are open to "novelty, complexity, and diversity" (p. 177).

In a manner that is consistent with Wenger and Snyder's (2001) description of communities of practice, Foxtrot's founding team self-organized around the specific project of working with an existing off-patent drug and developing it into a new drug, which they hope will ultimately treat fibrosis. Foxtrot's community of practice is more epistemologically diverse than it is expansive. The core group of company scientists represent a requisite variety of disciplinary, clinical, research, and study design experience. At the time of this study, there was no evidence of significant collaboration beyond this core group.

A limited number of students and research assistants have participated in Foxtrot related activities and are peripheral to Foxtrot's community of practice. Student participation has been limited because of intellectual property concerns. From the perspective of graduate students seeking to build their CV's, Foxtrot's IP position largely restricts publication activity. From the perspective of the university and Foxtrot (which share the ownership of Foxtrot's IP), the hiring of students would give ownership of some IP to the students. Consequently, Foxtrot has benefited from the work of a post-doc (who is considered a university employee) and some research assistants who work in the respective labs of some of the core group of founding scientists. As one respondent noted about research assistants:

> The relationship is really from a technical perspective. It's really that I employ them, and they're doing some work for me and the company. So they're part of the team, but not part of the core, they're part of [my] team (Respondent #15).

Research assistants have tested drug compounds, looked at protein interactions, and conducted some animal tests. One post-doc, Rico Ceconi, has played an instrumental role in Foxtrot's R&D in that he has made each of the company's molecules.

> He's really been a crucial person in the company because he's the only one that's making these molecules. He's making new molecules; he's got a background in total synthesis, but he's also been able to manufacture kilogram scales of these molecules, which from a chemistry perspective is a non-trivial exercise, so he's really been quite special in enabling this project to go ahead, because not only can he make the new things that enable the patents, but he's also been able to make sufficient amounts of material to facilitate the animal studies going ahead (Respondent #1).

In summary, Foxtrot's social structure is a self-organized and multi-disciplinary team whose members generally work in close proximity to one another as a community of practice. They self-organized around a project that pre-dated the commercialization efforts that led to the founding of Foxtrot. Each remains committed to Foxtrot's R&D to the extent that they continue to play a vital role in the project. The social structure is epistemologically diverse but relatively closed from external collaboration, which reflects the early stage nature of the company and the pre-clinical-trial stage of the core R&D project.

Institutional factors

A variety of institutional factors contribute to Foxtrot's lack of transparency. Foxtrot is a young, private company whose financial stakeholders consist of venture capital investors. The company has not yet embarked on clinical trials. Thus, as an R&D stage company, Foxtrot is still heavily engaged in the research aspects of its business. Intellectual property protections have been critical for Foxtrot in signalling its commercial legitimacy.

As a drug development company with no products to market and little intellectual property to exploit, Foxtrot faces a liability of newness (Hannan and Freeman, 1977; Stinchcombe, 1965) around the speculative nature of its business. Academic legitimacy is an important aspect of negating any speculation around the company's scientific base. However because it is a young company with pending patent applications, the IP protections are not firmly solidified to the point at which company scientists are actively presenting at academic conferences or publishing papers. Before the company secured financial resources from venture capital investors, the National Institutes of Health (NIH) in the United States did provide the company with a critical vote of credibility that ultimately positioned it as an academically legitimate enterprise. The NIH is conducting an important piece of the company's R&D, which the company would otherwise have to self-fund. As a quasi-academic entity, any meaningful support from the NIH carries the weight of academic legitimacy.

Many of the Foxtrot respondents recognized the long-term value in gaining academic legitimacy as an enterprise. Academic legitimacy is an aspect of the company's long-term marketing and fundraising strategies. Foxtrot is concerned with disseminating important findings through a top-tier publication. As one respondent noted, an association with a top-tier publication provides scientists with long-term lucrative funding options.

> We're aiming to put together a large publication on identification of the drugs and how they work, but we're not in a hurry because we know we've got this stuff off the way, we're the only ones who are working on it. We prefer to take our time to get a really significant publication in one of our major journals... Getting the science out there so that you can get the funding without a doubt and if your first with a big story obviously you could publish in a big paper. If you come in second you have to think of a slight way of making it different but you're in a much lower journal which means your less likely to get money (Respondent #6).

Once the company sufficiently secures intellectual property protections on its drug compounds, Foxtrot scientists expect to disseminate important R&D findings through the publication of papers and presentations at conferences. One respondent reflected on this and likened such dissemination to both company marketing and broader knowledge transfer.

> Well that is a knowledge transfer thing isn't it? That's the way to get the message out into the community, that you're looking at down the track, so you need to tell your academic colleagues what you're doing, and that you're setting – that you're establishing this company with this data, but you also need to tell the broader pharmaceutical community that you've got this company. So it's a bit of marketing really (Respondent #15).

The cautionary position that Foxtrot is taking by timing the release of a major article once it is based on adequately protected intellectual property is consistent with views expressed by venture capital professionals. As one venture capital professional articulated:

> You've got to be careful in terms of what you put in the public domain. You want to put in enough to get people excited but you don't want to put in enough that people can just leap straight onto your heels. In some situations you may put everything into the public domain on the basis that no one can catch you, but usually not (Respondent #9).

Numerous efforts have been made to champion Foxtrot as a venture and to signal the legitimacy of the company and the R&D of its drug development project. Company co-founder and CEO Jerold Carlsten has evolved into the role of Foxtrot's key *champion*. Foxtrot is one of the companies in my sample that benefits from the skills of an individual champion who has developed the ability to speak with credibility on both academic and commercial matters related to the company. As a medical researcher who also has a diploma in business as well as experience consulting with pharmaceutical companies, Jerold Carlsten is Foxtrot's champion – as identified by other company respondents. He has been part of the company's 60-70 presentations to venture capital professionals, which has entailed the framing of the company's narrative around a line of research that shows promise in the development of a drug treatment for fibrosis and which is backed by a growing list of IP protections. An individual associated with the venture capital and managerial aspects of Foxtrot emphasized the importance of this role.

> Technology commercialization really depends on an internal scientific champion. So one of the researchers going to champion commercial development and the opportunity, it's really difficult for us to do it. I've got a specific case that I'm working on right now. There's a lot of opportunity in it but we've yet - I've yet to find within the group a champion that's willing to take on the leadership for driving the technical development of the commercial opportunity (Respondent #12).

Foxtrot also benefited from the assistance of University Enterprises in the championing of the company and the construction of its narrative. University Enterprises helped the founding scientists refine their business case, which they would eventually pitch to venture capital investors. They also helped them adjust their initial R&D by increasing the potency of the existing off-patent drug in order to strengthen the venture's IP position and attract potential investors. In essence, University Enterprises helped the founding scientists negotiate an aspect of commercial institutional norms (i.e. the desire for strong IP protections) by providing then with advice about how to adjust the focus of their practices (i.e. the R&D around the anti-fibrotic qualities of a drug). University Enterprises also helped Foxtrot network with venture capital firms (Jain, George, and Maltarich, 2009) and champion the overarching ideas and intellectual base of the company.

In summary, Foxtrot is not a very transparent company. The current lack of transparency around the company's knowledge base is indicative of the efforts to strengthen the intellectual property position of the company. Foxtrot received its first major source of venture capital funding in 2009. Venture capital funding – as well as the company's growing intellectual property portfolio – are indicative of its legitimacy as a commercial enterprise (see Higgins and Gulati, 2003). As the company's R&D activities advance toward clinical trials, the academic credibility and efficacy of these trials will be critical for marketing the company to investors and the securing of subsequent funding.

Creating knowledge

Various patterns and routines are present within Foxtrot's community of practice, which are indicative of the ways in which the company creates knowledge (Nelson and Winter, 1982). One such routine is the production of drug molecules in one lab, which is followed by sending them to another lab for animal model and cell culture model tests to determine the potency of the molecules. As a result, tacit knowledge becomes embedded in these routine back-and-forth interactions. One respondent describes this routine in detail.

> So, basically what happens is that [Tim] would make a series of compounds, then give us the compounds to do proof of concept studies in animal models and cell culture models. So we can then work them up and say how potent the compounds are, and then potentially we can take them from there into clinical development... [The routine occurs] several times a week. There's people coming back and forth between the two laboratories. All the time actually, that's part of the interaction that's worked really well... One of our advantages of this collaboration is I've actually learnt more about chemistry than I would ever come across and vice versa, he's learnt a lot about bio-medical research (Respondent #15).

Because these scientists in the Foxtrot community are generally working together in close proximity, they are learning from one another about the other's respective discipline and how it applies to their own work. This is consistent with Nonaka and Takeuchi's (1995) pattern of *socialization,* as a form of knowledge creation and tacit knowledge transfer. As such, Foxtrot is an organizing mechanism that enables such patterns of socialization and knowledge creation.

Foxtrot's interdisciplinary nature has enabled it to create knowledge through the novel combinations of its founders' respective expertise. The commercialization of Foxtrot and its organization as an R&D project yields an axis around which the various sources of knowledge can be applied. Foxtrot is a not a garbage can model of organizing

(Cohen, March, and Olsen, 1972) in which scientists of various disciplines and persuasions are searching for ways to apply their logics to undefined problems. Instead, Foxtrot is an organizing mechanism around a practical drug development challenge that outlines defined needs to which an interdisciplinary community of scientists can attend. As an organizing mechanism for interdisciplinary knowledge creation, Foxtrot enables the conscious sorting, grouping, matching, and combining of expertise, which the company CEO (who is also a founding scientist and member of the community) coordinates (see Leonard and Sensiper, 1998).

As a company that is organized around a drug R&D project, Foxtrot is addressing a practical societal need by creating knowledge (Popper, 1972). Furthermore, the company adheres to a constructivist perspective of knowledge creation (Knorr-Cetina, 1981). In the course of commercializing, the founding scientists had to organize their efforts around the creation of molecules that would ultimately increase the potency of the existing drug, which formed the basis of their R&D. The decisions to create knowledge in this regard were made with an interest in strengthening their intellectual property position in order to attract investors. Thus, the founding team was creating knowledge that was contextually specific to the commercial sector, which would ultimately fund the venture and enable it to further address its overall mission of developing a new drug.

Discussion and conclusion

As communities of practice, the study of Alpha and Foxtrot yielded some interesting findings about the creation of knowledge. The close proximity among scientists in each of the companies indicated social proximity and trust, which facilitated mutual learning over time and the transfer of tacit knowledge. The richness of this tacit knowledge was embedded in these communities of scientists, which consequently embedded into the social structure of both companies. Proximity also enabled the routinization of various knowledge tasks, and these routines embedded the flow and transfer of knowledge. The communities of practice behind both Alpha and Foxtrot included collaborative ties to other scientists at different universities around the world. The structure of both companies acted as organizing mechanisms through which these extra-local ties could contribute to the communities of practice. For example, Alpha's community includes a key collaborator in Boston, and the company provides a framework through which this individual can collaborate with researchers in Australia. Similarly, one of Foxtrot's key collaborators is located in Canada. In both cases, the extra-local collaborators have a personal history and established trust with the other members of the community, which provides them with social proximity to the other members of their respective communities and enables them to work within the parameters of the company R&D projects.

One of the aspects of communities of practice that was evident in these two companies was the extent to which company scientists maintained independence from each other and from the company, despite their physical and social proximity. Many of the collaborating scientists in each company maintained their own independent labs and were, therefore, embedded in a variety of different collaborative networks. For these scientists, their affiliation with their respective companies is part-time and based on contract. Their roles as company scientists are among a list of other projects in which they are involved. This rich web of networks among company scientists puts a diverse array of intellectual resources at the disposal of each company and strengthens its requisite variety of knowledge.

The role of the university has interesting implications for academic spin-off companies that are organized as communities of practice. The university from which a company emerged continues to play a role in the company to the extent that its scientists are engaged in university research. In the case of Alpha and Foxtrot, company scientists continued to work as university scientists, which consequently put university resources at the disposal of each company. A point of departure between both companies was the extent to which the University of the Southern Hemisphere played a role in the commercial aspects of each company. Alpha was established outside of any technology transfer channels, while Foxtrot greatly benefited from technology transfer channels. Therefore, the university continues to play a role in the commercial matters related to Foxtrot but not for Alpha.

This chapter illustrates two companies that each benefit from an internal champion who is skilled at both academic and commercial aspects of their respective companies. In both cases, the champion is an academic scientist who speaks with credibility about matters related to the company's scientific research base, which acts to strengthen the legitimacy of the enterprise, and the champion also demonstrates a level of business literacy that enables them to effectively navigate the commercial terrain of their respective ventures. Existing scholarship that university technology transfer offices often assume many such roles of the championing of academic spin-off companies. However this chapter illustrates the ways in which an academic enterprise (Alpha, in this case) can champion itself in the absence of a technology transfer office.

In conclusion, this chapter illustrates two academic spin-off companies that organize as communities of practice and engage in knowledge creation that supports long-term R&D projects. The knowledge that each company creates is contextually driven by its R&D goals as well as by the providers of funding that ascertains the commercial legitimacy of the enterprise. Both companies share a common tie to the University of the Southern Hemisphere, yet other universities play important roles in the activities of each company. In the case of Alpha, both the University of the Southern Hemisphere and Ivy League University offer the intellectual and scientific origins of the company, which suggests that an academic spin-off company is not always traceable to a single organization. Each company's academic connections are important aspects of its legitimacy as an enterprise, but academic legitimacy manifests in different ways based on the life cycle stage of the venture. Collaborative ties also diversify the requisite variety of skills and expertise that contribute to the work of each company.

Chapter 7 – Academic Spin-off Companies as Hierarchical Firms

Introduction

This chapter presents two companies – Beta Health Services and Echo Technology Solutions – whose social structures most closely resemble that of an archetypical *hierarchy,* with a clear division of labour and function among members. Colloquially, these companies "look what one might expect to see" when they envision a company and visiting it. Each company has a dedicated office space and employees who work there. They are both locally based, and each is located within a short walking distance to the University of the Southern Hemisphere campus. These companies are organizationally independent from the university community. In this sample, university technology transfer channels did not actually "spin-off" these companies. Instead, company founders launched each respective company through their own efforts by securing financial resources from investors.

The goals of both companies differ in content, but each founder launched their respective company with the intent of applying academic knowledge to the addressing of specific niche industrial needs. Beta's founders addressed a need in the pharmaceutical industry by developing a cognitive test that could be easily administered as part of large-scale clinical trials. Echo's founders recognized the drawbacks in existing technologies that detect radiation and developed a new technology that overcomes these limitations and is applicable across a wide range of industries, including medical technology and defense. These two companies have the strongest exploitation aspects of their respective strategies because, unlike the other companies in my sample, they were founded with the ability to immediately market products in the commercial marketplace. Each company strategically balances this with varying degrees of exploration activities, which balance their strategies. Consequently, the scale and scope of the exploration aspects of these respective strategies differ and also impact the extent to which each company is collaborative, transparent, and ultimately engaged with academic research. Each company maintains idiosyncratic relationships with the University of the Southern Hemisphere. Furthermore, each company is agnostic toward the University of the Southern Hemisphere and considers the university one of many current and potential collaborators.

Beta Health Services

Goals and strategies

Beta Health Services is a medical software company that markets cognitive tests and related services to pharmaceutical companies and other research organizations. The cognitive tests that Beta designs and markets are utilized in the context of clinical trials and other large scale research programs in which researchers desire to measure change in cognitive function in populations of people over time. Beta was founded in

1999 and has been marketing its tests since its founding. It has been a publicly traded company since 2004.

Strategically, Beta maintains a balance between exploration and exploitation of knowledge (March, 1991). Beta is able to exploit its testing product as its core intellectual property by directly earning revenue from it. The company is also strategically focused on exploring new uses for its tests, participating in related research studies on cognition, and generating new knowledge in order to continuously demonstrate the efficacy of its tests.

> The potential of this technology, of the core technology we've got is enormous in many, many areas that we haven't even had time to even think about, let alone – well, we've thought about lots of them, but have not had time to develop at all (Respondent #2).

Beta supports this exploration by incorporating an extensive student-based research program into its organization. Among the companies in my sample, Beta most exhibits a long-term strategic balance between exploration and exploitation of knowledge and, consequently, the balance between short-term revenue generation and long-term investment in projects (see Simsek, Heavey, Veiga, and Souder, 2009; Tushman and O'Reilly, 1996). It is also the only company in my sample that extensively incorporates students into its organization.

Beta is organized as a hierarchical firm with dedicated office space and staff. It is organizationally separate from universities or any other entities. The company consists of 30 employees. It is roughly structured into a small leadership team and a small research team. Included in the mix are information technology staff and programmers, finance and billing staff, statisticians, and staff psychologists. Beta also involves students from local universities to work on a variety of research projects for the company. Currently, four doctoral students, three Masters students, and honours year undergraduate students work on Beta related research projects. Beta's office location is roughly a ten-minute walk from the University of the Southern Hemisphere campus and a ten-minute walk from a second university campus – a technical university. Many of Beta's students come from these two universities. In 2006, Beta opened a second office in the northeast United States in order to support one of the company's major U.S. pharmaceutical clients. Through some of its scientific collaborators, Beta has also had a presence in London.

Among the companies in my sample, Beta is the most transparent and one of the most globally and epistemologically networked organizations. The company has relatively little intellectual property that it protects. The software algorithms for its cognitive tests are protected. Otherwise, the company openly disseminates its knowledge through academic channels and maintains a culture of transparency in order to continuously signal its academic credibility. Beta's research collaborations globally extend to multiple researchers at various universities around the world and incorporate a diversity of expertise. Despite this transparency, much of Beta's competitive advantage is rooted in the tacit knowledge of its team.

Epistemological factors

Beta originated as a collaborative effort between two scientists who combined their diverse backgrounds in order to address a practical need in the area of cognition research. Gordon Kirts was a staff neurologist at a local hospital with a non-faculty appointment at the University of the Southern Hemisphere. Through his work, he was involved in the hospital's dementia program and worked to develop cognitive assessments. He also had a personal interest in computer programming. As a result of these interests in programming and cognition, he sought to develop a web-based, culturally neutral, computerized test of cognition, which he recognized was an unmet need within the context of the administration of large-scale research projects. Kirts contacted Lewis Caples, who was a colleague with whom he had previous contact through professional conferences and associations. Caples was a neuropsychologist with a lab at another local university who had an interest in mental health research and who was an experienced methodologist in that field with a wide range of collaborations across interest areas. Consequently, these two researchers combined their respective areas of expertise to a shared goal (see Leonard and Sensiper, 1998) and successfully developed a cognitive test. Such patterns of combining diverse intellectual perspectives to shared goals have continuously exemplified Beta's corporate culture and exploratory strategy of knowledge creation and have also broadened the company's collaborative network structure.

One aspect of the company's connectedness that supports its exploratory strategy is the extent to which Beta is a social learning space for an extended network of student researchers. A research team is an aspect of Beta's organizational structure. Unlike other companies in my sample that largely avoid involving students in commercially related research activities, Beta embraces them. Lewis Caples directs Beta's research activities. He also maintains an adjunct academic appointment at a local technical university. Caples's ties to the local academic community put him in touch with students whom he has recruited to work at Beta on various research projects. At the time of this study, four doctoral students, three master's students, and honours year undergraduates work on Beta projects. This mix is comprised of students from both the technical university and the University of the Southern Hemisphere.

Beta designed a mutually beneficial student research program in which the company benefits from the manpower and diverse expertise of the students, while the students benefit from the opportunity to work in a commercial environment and to publish research papers from data. This arrangement blurs the boundary between academic and commercial activities.

> In fact if you could come in here and sit around and I led you in blind folded and sat you in the corner and let you make observations for a day, I reckon you wouldn't know whether you were in an academic environment (Respondent #5).

On the one hand, Caples mentors students in a manner that resembles that of an advisor-advisee relationship and gives them freedom to pursue projects that interest them. On the other hand, projects must relate to Beta's mission, and the work is largely conducted off-campus at the company's workspace. Kirts and Caples summarized the nature of the company's relationship with students.

> They do a lot of primary R&D that we otherwise wouldn't have the funds to get done. We – the things they do are small components of larger pictures, so when we help them get experience in a commercial environment in terms of doing research which is going to help us commercially. But also give them a chance to write up papers, and get their first publications. They help us with manpower basically and some expertise in the sense that they have lecturers and other people to help them. They have time to do interesting studies and they have some background usually – psychology or research methods – that allows them to slot in quite quickly (Respondent #2).

> So if you came through and I have a meeting with you and you look like you're maybe immature, you're one of those students that comes through school and really just being cloistered. Then I'll set you a project that pretty much you stay right under my wing. I don't let you outside, but I'll give you something and okay well I've got this problem now, there's a construct that we've been looking at and I really don't know how it works and here's two or three experiments that would really help us understand that and so off they go (Respondent #5).

Research collaboration that utilizes the company's cognitive test or supports its research efforts in human cognition is strategically critical for Beta. The hierarchical (and non-virtual) nature of the company illustrates the dynamic of the company's collaborative efforts. One the one hand, the student research program incorporates students into the formal structure of the company's activities. On the other hand, Beta maintains a variety of ties to other individuals and organizations beyond its internal social structure. Some of the company's collaborative ties extend to individual researchers at various universities around the world who are using Beta's tests in their research studies or who are doing research that is relevant to Beta's overall research agenda on the measurement of human cognition. Lewis Caples sits on dissertation committees of doctoral students whose advisors collaborate with Beta and whose dissertations relate to Beta's research agenda. In his role as research director, Caples plays an especially central role in maintaining the company's academic ties by bridging structural holes and broadening the company's network (Burt, 2004, 1992). Alternatively, the company maintains collaborative relationships with its customers. Many of the world's largest pharmaceutical companies are Beta customers. The relationships with these companies are more than just transactional. They are relationship driven in that Beta seeks to learn from these companies and their research studies to the extent that it enriches its own knowledge base.

Interestingly, Beta also illustrates the drawbacks of strategic level collaboration that exceed a company's core goals. At the time of the company's initial public offering of stock in 2004, Beta had diversified its business and expanded into drug development by in-licensing Alzheimer's disease and Parkinson's disease drug development projects from other biotechnology companies. The company undertook the drug development projects in an effort to raise the value of its IPO. Much of the work for these projects was subsequently contracted to scientists in external labs. Consequently, the company's role in these projects was mostly project management. The drug development projects did not fit with the original motivation for the founding of the company in order to provide cognitive testing products and services. The drug development projects distracted the company from its core product and drained financial resources, despite their role as a means of attracting additional funding. Consequently, the company divested these projects in 2005. These projects gave the company a greater level of requisite variety of knowledge resources and available expertise (Weick, 1979; Ashby, 1956) while broadening its external network. However the projects complicated the company's exploratory strategy by not directly relating to the knowledge resources around its cognitive tests, which the company was already able to exploit.

In summary, Beta has a widespread collaborative network that extends beyond the boundaries of the formal social structure of its firm. These collaborations support the company's exploratory strategy of developing new uses for its cognitive tests and for conducting research on related aspects of human cognition. The company also has a straightforward strategy of marketing its cognitive tests to users who pay the company a license to use it. In doing so, it is exploiting its knowledge resources. In many ways, its collaborative activities support both its exploratory and exploitative strategies in that it collaborates with those to whom it sells, and vice versa. Collaboration increases the requisite variety of Beta's knowledge resources, but it also embeds those knowledge resources in the hands of its collaborators.

> We talk about it as much as we can whenever we can and we basically have built up quite a large collaborative network by doing that, maybe between 60 and 100 different sites around the world that are using our tool. Then we also get credibility when we work with drug companies who then – the turnover in drug companies is quite high. Some people go to academia, some people come from academia, and so that also helps in terms of people knowing about us and talking about us and using us (Respondent #2).

As such, students and other academic and industrial collaborators contribute to Beta's knowledge base, but they also utilize Beta's knowledge resources in their own work, which effectively spreads awareness and application of the company's cognitive tests.

Institutional factors

Strategically, Beta is a very transparent company in that it regularly disseminates knowledge related to its activities through academic channels. This transparency is a function of the company's need to continuously signal the academic credibility and efficacy of the core asset that it exploits in the marketplace (its cognitive test), which subsequently legitimizes the overall business. Despite having earned revenue from its cognitive tests since its inception as a new venture, the company has still not turned an annual profit. Therefore, its commercial legitimacy (to the extent that shareholders accept the company as a viable long-term investment) directly relates to its academic legitimacy (to the extent that its cognitive test works and is scientifically credible).

Unlike the drug development companies in my sample, which engage in extensive R&D in anticipation of an eventual drug product, Beta's cognitive test "product" was marketable very early in the company's existence. Alternatively, Beta offered a marketable "product" as soon as it became an established business venture. The company's initial private investors gave Gordon Kirts and Lewis Caples a limited amount of start-up capital and a three-month time frame to develop the cognitive test. They successfully developed the test and ascertained its validity. This boosted the company's credibility and enabled it to market its test and raise revenue. Beta has been operational for over a decade, and during this time its cognitive tests have been successfully utilized in a variety of clinical trials and research settings. Thus the company no longer suffers from a liability of newness (Hannan and Freeman, 1977; Stinchcombe, 1965), and it arguably has crossed an academic legitimacy threshold (Rutherford and Buller, 2007) in which any fundamental academic questions of the company's test have been adequately addressed.

Despite having crossed a basic legitimacy threshold, Beta continues to strengthen the credibility of its tests and promote its overall academic legitimacy. Its researchers participate in academic conferences and publish papers. The peer review process legitimizes their work, and this academic legitimacy further serves as a commercial marketing strategy. As one respondent noted:

> In terms of a marketing strategy… It's very important, and particularly in the early days, 'Tell us about the academic research that's been done…' 'Tell us, show us the papers that analyze the efficacy…' and so on… These pharmaceutical

companies are investing very big money… so to have a little Aussie software company waltz in the door in New Jersey and say, 'Hey, we've put the best thing for you,' they need to be really confident that our science is good, our quality… and so on is good (Respondent #11).

The marketability of the Beta's test relies on its applicability in many testing scenarios. So while the company is able to exploit its knowledge resources in the commercial marketplace, it continues to explore new knowledge and strengthen its test in the academic context in order to avoid any mishap or validity issue in the commercial space. Although the company is raising sales revenues, it continues to remain unprofitable. Therefore, Beta cannot afford a negative issue around the validity of its core cognitive test product and must continue to sustain its academic legitimacy.

Unlike a drug development company that can protect molecules and chemical compounds as intellectual property, Beta has little IP that it can protect. As a result, much of Beta's knowledge has been disseminated through academic channels such as publication and conference presentation. The company is very transparent, as the academic legitimacy of its knowledge base is fundamental to its commercial success. Its academic legitimacy is not rooted in a tie to a single university; rather it is rooted in its extensive collaborations and participation within a global network of academic colleagues.

We try and collaborate widely; we try to do as much ongoing research with academics as possible, mainly because the applications of our technology are so

> wide, so broad. Having collaborations with the [University of the Southern Hemisphere and other local universities], with other universities in different parts of the country and with universities in America and Europe and really pretty much all over the world is the way we gain credibility to then sell this product into trials for pharma companies (Respondent #2).

Beta's path to commercial legitimacy was not a function of formal university technology transfer channels. No university technology transfer office played a role in championing the company. Beta's founders benefited from personal networks of individual investors who had a trusting relationship with the founders and understood both the scientific and commercial potential of what the business venture offered. Beta emerged from academic ideas, but no university technology transfer office "spun off" the company or helped it navigate the commercial sector. Beta has few formal ties to the University of the Southern Hemisphere, as the development of the cognitive tests did not originate from specific work that occurred at the University of the Southern Hemisphere. In fact, in the process of establishing the actual company the University of the Southern Hemisphere was asked and agreed to acknowledge that it had no intellectual property claim to the company. Once established, Gordon Kirts and Lewis Caples received adjunct faculty appointments at the University of the Southern Hemisphere as well as honorary appointments at the university's centre for neuroscience. They have no official responsibilities to the University of the Southern Hemisphere. However they occasionally lecture at the university.

In summary, Beta is organized to promote its overall academic credibility and legitimacy in an effort to directly affect its commercial legitimacy and success. Its organization promotes transparency in the context of the relationships that it establishes with academic and industrial scientists and collaborators. Beta researchers actively publish papers and present at academic conferences. These activities are emblematic of the company's academic legitimacy. As such, the company does not seek an exclusive relationship with any one university or academic institution, but it instead relies on this widespread engagement with the global academic community.

Creating knowledge

A unique aspect of Beta's organization is its social structure as a learning space for students, as identified by intellectually rich patterns of knowledge creation. In this learning space, students are mentored in the research that they conduct, and the subsequent results of their work contribute to the knowledge base of the organization. Because students routinely work at the company's office location under the supervision of Lewis Caples, Beta resembles a traditional academic learning environment in which tacit knowledge is developed and shared in an atmosphere of close collaboration between a mentor and a student. This is the *socialization* form of knowledge creation in which tacit knowledge is transferred and new meanings and insights are created (Nonaka and Takeuchi, 1995). The development of tacit knowledge and a network of researchers who use Beta's tests are important for the success of the company. The company's local location in the vicinity of universities supports this. Despite the lack of formal ties to any one particular university, the company maintains connections with universities as a way of reaching out to local pools of expertise for transferring tacit knowledge (see Audretsch and Stephan, 1996). Because of the company's transparency, student research results are disseminated, which makes the students and the company agents of knowledge transfer. In essence, Beta's social structure is an organizing mechanism that works through a revolving door of students who learn as well as create and disseminate knowledge in an established rhythm and work routines (Bauer, 2007; Nelson and Winter, 1982).

Interestingly, the organization of Beta as a venture provided its founders with a flexible social structure that was independent of their respective universities in which to pursue their ideas about cognitive testing. The company's social structure was sufficiently flexible for the co-founder's intellectual pursuits, which ultimately resulted in a knowledge-creating company.

> He (co-founder) was very pleased to be able to work in the business because of the much more excitement than just continuing academia. Because he gets, he gets the best of both worlds (research and practice)… I think (other co-founder) enjoys the same environment and they get to swan around the world and influence neuroscience at a far higher level than if they'd just remained at a pure academic situation. They've thrived in that environment (Respondent #11).

The company enabled them to fully develop their test and validate the test through its use by customers – mostly large pharmaceutical companies – and by academic collaborators.

All projects in which Beta collaborates ultimately must have something to do with the company's mission and must not conflict with that mission. As such, Beta's knowledge productions are contextually specific constructions that adhere to the interest structure of the organization (see Knorr-Cetina, 1981) of generating the best cognitive test that holds an intellectual monopoly of sorts in the commercial marketplace of such tests (see Latour and Woolgar, 1979). As one respondent notes, Beta's collaborative relationships must ultimately create knowledge that benefits the company.

> So often times generally, it works very simply, that is that [a] professor has a problem, I have a solution. The solution involves Beta technology or ideas... And so one example might be that the professor then says, 'Well I don't want you to do so much of that Beta stuff, I want you to start working on this other stuff.' To which I say, 'That's not the project, I have no expertise in this other stuff' and then they might say or alternative and ultimately if you can't resolve it I just always say look, I want Beta, I have to have something to do with Beta for me to collaborate it and if it's not I'm conflictive, right, I can't give you advice about things that might either compete with Beta or things that don't involve, because I haven't got enough time to be talking about something else.

In summary, Beta is a globally networked, knowledge creating company. As a commercial entity, Beta markets a tool that contributes to the efforts of researchers in conducting large-scale studies. Through its strategy of exploitation, Beta raises revenue from its cognitive testing application. Through its strategy of exploration, Beta creates knowledge around the application of this test. The cognitive test is an enabler of knowledge creation. It is the basis of ongoing research studies that the company internally conducts through students as well studies in which the company externally participates through collaboration with customers and academic partners.

Echo Technology Solutions

Goals and strategies

Echo Technology Solutions is a small company, founded in 2004, which is based on founder Rick Avans's technology that he developed while pursuing a PhD in electrical engineering at the University of the Southern Hemisphere. The company strategically balances exploitation and exploration around its core digital pulse processing technology (Simsek, Heavey, Veiga, and Souder, 2009, March, 1991). The exploitation aspect of its strategy is the marketing of this core technology in a variety of industries and applications. The company's core technology is applied to business activities in four major categories – medical imaging, defense and security, minerals exploration and analysis, and materials analysis. The exploration aspect of the strategy is the search for new innovative industrial applications for the technology, which necessitates the navigation of adjacent areas of knowledge in order to discover these new possibilities. The balancing of exploitation and exploration are elements of the company's ambidexterity (Tushman and O'Reilly, 1996), which is meant to ensure the its continued financial growth.

The organizational structure of Echo is relatively simple. The company has three employees. Rick Avans is the technical director of the company and is responsible for the R&D and technical aspects of the company's development. There is a managing director of the company who is largely responsible for business development. There is also a chief technology officer and a non-executive board chairman. The company also employs consultants in the areas of intellectual property management and computer programming. At the time of this study, the company was looking to add a few additional employees in the areas of business support and technology development. The company is based in a small office location in a suburb near the the University of the Southern Hemisphere campus. The chief technology officer is based in a satellite city approximately 130 kilometres from the company, but he works from the company's offices twice a week. Although the company is very small, it has an organizational structure with defined roles and responsibilities. These attributes therefore characterize the company as 'hierarchical' rather than as 'virtual.'

Epistemological factors

The organizational structure of Echo reflects an interesting evolution around founder Rick Avans's goal of commercializing technology that he developed during his doctoral studies at the University of the Southern Hemisphere. The social structure leading to the formation of Echo was initially characterized by a community of practice whose goal was to ascertain the commercial potential of Avans's technology that he developed through the course of his doctoral studies. This community of practice took the form of an interdisciplinary team that entered a business plan competition with a commercialization plan for Avans's technology. The team met its goal by placing second in the competition and attracting the interest of an investor who would eventually support Avans's efforts. With the founding of Echo as a company, its social structure has since evolved into a more formalized system with clear roles and responsibilities for the members of the company, who devote their full time efforts to the venture.

As a doctoral student in electrical engineering at the University of the Southern Hemisphere, Rick Avans pursued his interest in the development of detection technologies for land mine clearance in the humanitarian context. During this time, he worked to develop a specific technology that improved the accuracy and speed of the detection of radiation. Existing gamma ray detection suffered multiple practical drawbacks in that the detection signal was either slowly generating weak data or rapidly generating mostly corrupted data. The knowledge that Avans developed around digital pulse processing in the course of his studies enabled him to create a technology that overcame existing limitations. In essence, he started with a practical problem and created knowledge around solving it (Popper, 1972)

During his time as a doctoral student, Avans entered a business plan competition through the university's business school on a team that included a personal friend who was enrolled at the school. This team resembled a community of practice in that it was informally bound by the shared objective of determining the commercial applicability of the technology that Avans had developed (Wenger and Snyder, 2001). The social structure of this team assembled an interdisciplinary mix of both academic and business knowledge in order to discover potential applications for a technology. A team for an academic business plan competition also represents an alternative to discipline-specific academic organization, as it gave Avans a mechanism by which to expand beyond the traditions of his academic department and to discover novel possibilities around his work (see Simonton, 1983). The team was successful in the competition. They won some money, and they also won the support of someone who would ultimately invest in what was to become Echo.

The current social structure of Echo is relatively closed – as the company does not collaborate with many external partner organizations. The company did rely on the expertise of an external IT/system architecture firm for programming and the writing of computer code, which enabled the technology to move from a concept to a solution. The founders remain in close contact with the University of the Southern Hemisphere through personal connections, which include connections with colleagues in the school of engineering and University Enterprises. The company is open to future university collaborations in support of the exploration aspects of their strategy (University of the Southern Hemisphere or elsewhere) to the extent that such collaborations enable them to discover new applications for their core technology. As one respondent noted about the company and its collaborative relationships:

> We're effectively an intellectual property design house and we're focused on designing and extracting and licensing intellectual property... We want to remain

> very focused on developing the best technology we can with these applications. And in solving our customer's problems when they come back and they say 'well this is not working for us.' So we see in the near future probably having a stronger role with the university in terms of... progressing in different technology areas. I guess we see that potentially we're a good vehicle for extracting technology out of the universities in this particular space (Respondent #13).

Once Avans founded Echo, much of the company's efforts were aimed at the securing of its intellectual property from the university and other sponsoring parties. This necessitated an emphasis on the exploitation aspects of the company's strategy because IP protections would enable the company to market its technology while simultaneously protecting it. Consequently, the exploration aspects of the strategy were secondary, and the company was neither widely collaborative nor aligned with academic research activities. In recent years the company has presented at academic conferences, but it has done so for the purpose of discovering adjacent opportunities for the application of its technology.

> Now that we're presenting conferences people come to us with applications that we've never heard of. But that wasn't the marketing technique that was available to us until we felt more comfortable about the IP protection (Respondent #13).

> We've really only done a lot of public access or academic access presentations more recently… and that's on the back of every patent granted. So once your patent's granted and the paper details it goes into some or obviously quite a lot of detail about the process that our core technology follows, then the risk gets significantly diminished (Respondent #14).

Because of the technology's potential application in a range of disciplines, including medical imaging, mining, and security, much of the company's current efforts involve a navigation of various knowledge areas. By beginning to present at academic conferences in 2008 and seeking novel combinations of knowledge around his technology, Rick Avans is shifting focus toward the exploration aspects of his company's strategy.

In summary, the organization of Echo reflects efforts to commercialize the efforts of Rick Avans's academic research. A business plan competition – organized as a community of practice – was responsible for generating momentum that led to the founding of the company. Once founded as a company, Echo was organized to continuously market Avans's core technology and explore different applications for it. Both the community of practice and the established company of Echo were organizing mechanisms for advancing knowledge from a scientific construct to a practical technology. In doing so, external collaboration has been minimized at the interest of other priorities related to the exploitation aspects of the company's strategy.

Institutional factors

A major driver of Echo's structure is the inter-institutional dynamic between the company's origin in a university research setting and the efforts that its founder undertook to isolate the technology from the university and acquire full ownership of it. Echo is very protective of its intellectual property, which obscures the transparency of the company's knowledge base and limits its interactions with the academic community. Consequently, efforts at achieving commercial legitimacy ahead of academic legitimacy characterize Echo's path to commercialization.

Echo has delineated a clear boundary between academic research and commercial activity. The University of the Southern Hemisphere, through a complex relationship with various corporate partners, formed a consortium that partially funded Avans's doctoral research. Consequently, this consortium retained ownership of the intellectual property that he developed through his studies. For approximately three years after formal establishment, the efforts of the company were directed at securing full ownership of its intellectual property from the University of the Southern Hemisphere and this consortium of funders. Because of concerns around intellectual property, any research that has been conducted around Echo's technology has been internalised and not publicly disseminated through academic channels in order to strategically maintain a monopoly over these knowledge-based resources for the purposes of commercial exploitation (see Knorr-Cetina, 1981; Latour and Woolgar, 1979). Rick Avans made a conscious decision to forgo an academic career in order to develop his company and the applications of its technology while separating the intellectual property from the university setting.

At Echo, the quest for academic legitimacy has remained a secondary priority to matters of commercial legitimacy and the securing of intellectual property protections for the company's technology and knowledge base. As a result, the company's social organizational structure has been relatively non-transparent. Beginning in 2008, Rick Avans has begun to present at some academic conferences, thereby increasing the transparency. These efforts have been aimed at marketing the company's technology and exploring for new applications of the technology rather than the dissemination of knowledge and the seeking of academic legitimacy. For Echo, the scientific rigor and integrity of the company's core technology was established while Avans was a PhD candidate at the University of the Southern Hemisphere.

> In the early days, in the very early days the company's first tick… we were quite focused on getting news releases out about this technology coming out of [the University of the Southern Hemisphere]. So getting our name associated with the university was helpful in terms of a granting exercise and whilst [University of the Southern Hemisphere] is not known massively overseas. If I'm overseas saying this technology has come out of [the University of the Southern Hemisphere] and someone searches the [University of the Southern Hemisphere] website and there's no reference to it, then it damages your - it doesn't damage it, it may not damage your credibility but having that reference

> there of you being in this university newspaper article or something like that or press release, it's just one level of credibility (Respondent #13).

As such, having the association with academic research has been a valuable aspect of the company's marketing strategy, but it is not the only aspect. For Echo, the applicability of the technology in a variety of industrial settings has been especially valuable. In other words, once the rigor of the science was established, it has been very important to the company that the technology works and that it has a narrative about what the technology does.

The institutional boundary between Echo and the academic community is clearly delineated. The company primarily resides in the commercial institutional space. As a result, it has relied on commercial symbols of legitimacy such as patents (Higgins and Gulati, 2003), business development grants, and business innovation awards. In particular, the first major award associated with the company was the second place finish in a business plan competition at the business school in which Rick Avans and others competed around a plan that became the basis for the eventual establishment of Echo. The company has subsequently received a variety of awards from various business groups.

The University of the Southern Hemisphere did not spin off Echo, as the company was not established through any formal technology transfer channels. Rick Avans was able to generate credibility through the course of the business plan competition, which served as a platform for the sharing of the narrative behind the commercial potential of his knowledge and technology. In this role, he became the company champion. One of the business plan judges – who himself was an entrepreneur – was receptive to this narrative and became an advocate for the idea behind the business and also played a role in the networking of capital for the company. His efforts helped legitimise the Echo enterprise in the commercial institutional space (see Morrell, 2008). Similarly, University Enterprises has shown an interest in the commercial success of Echo and has helped the company network for funds (Jain, George, and Maltarich, 2009; Colyvas et al., 2002). In this role, University Enterprises has been a mechanism for communicating the company's narrative despite its otherwise limited and informal relationship with the company.

Aside from the company's past intellectual property ties to the University of the Southern Hemisphere, Echo has no remaining formal ties to the university. The company exclusively owns its intellectual property. In the process of considering funding options, the company did approach University Enterprises and presented a proposal to a venture capital fund, but ultimately the funding from this source did not materialize. Despite this, Echo maintains a good relationship with the people at University Enterprises. Although there is no formal tie between the company and University Enterprises, the two parties remain in close contact. University Enterprises has promoted Echo in its published materials as a company with a rooted knowledge base in the university community.

In summary, Echo has been a relatively non-transparent company. The lack of transparency reflects its effort at establishing commercial legitimacy through the securing of its intellectual property. Such efforts would subsequently enable the company to exploit this intellectual property in the commercial- industrial marketplace. The credibility of Echo's technology and knowledge base was initially established during founder Rick Avans's doctoral studies at the University of the Southern Hemisphere. This credibility was sufficient at academically legitimizing the company and attracting investors through personal networks of the founder and his immediate collaborators. Upon successfully achieving ownership of its intellectual property, the company is becoming gradually more transparent in an effort to market the technology to new industries and to develop new applications. Therefore, academic legitimacy is an aspect of the company's marketing strategy, and it also relates to the company's efforts at finding adjacent opportunities by navigating a gradually expanding space of scientific collaborators.

Creating knowledge

Popper (1972) wrote that the world around us challenges us with practical problems that require novel solutions based on the advancement of science and the creation of new knowledge. He wrote, "We learn about our environment not through being instructed by it, but through being challenged by it" (p. 266). The challenge of humanitarian land mine clearance presented Rick Avans with just such a challenge, but the existing technologies were limited in their ability to address this problem. His academic studies, followed by his efforts to commercialize his findings, represent the codification of new knowledge-in-action as manifested in his technology. He continuously seeks adjacent industries in which to apply his company's core technology.

Such efforts offer the opportunity to create new knowledge around the role that his technology can play in the addressing of other practical challenges.

Upon successful securing of its intellectual property ownership, Echo has added flexibility at creating new knowledge. Intellectual property protections are integral to the exploitation aspects of the company's strategy. Consequently, the knowledge that the company has created or will create through the search for adjacent business opportunities will be contextually specific constructions of the practical needs of customers in various industries as well as the contingencies and constraints associated with intellectual property protections (see Knorr-Cetina, 1981). Echo represents an interesting example of a social structure whose knowledge producing capabilities were somewhat arrested by the constraints of intellectual property. Organizationally, Avans and his team brought order to an otherwise disorderly intellectual property ownership structure, which has subsequently positioned the company for the creation of knowledge and the development of an increasingly better technology platform through the potential pursuit of collaborative R&D relationships and business opportunities (see Patriotta, 2003).

Discussion and conclusion

This chapter demonstrates the ways in which intellectual property protections matter to a company and affect the extent to which the company is transparent. Despite both having their intellectual roots in academic research, the companies presented in this chapter widely differ with respect to their strategies around intellectual property protections for their knowledge. Beta is relatively transparent and collaboratively networked to companies and universities around the world. In contrast, Echo is relatively non-transparent, and it does widely collaborate with other partner organizations.

The two companies described in this chapter are social organizational structures that enabled their respective founders to enact better conditions in the contexts in which they work and in which their interests and passions lie. The founders of Beta organized to pursue their interdisciplinary interests in cognition, research study design, and computer programming in an effort to help large pharmaceutical companies design better clinical trials, which ultimately speeds the development of new drug treatments. The founders of Echo recognized a passion for humanitarian land mine clearance, and they consequently improved upon existing radiation detection technologies and assembled other intellectual resources in order to serve the original passion as well as to discover adjacent sectors in which the same technology could make a meaningful difference in people's lives. The founders worked in various capacities in the university research environment. Yet in both cases, they recognized that the university environment limited their abilities to pursue their respective goals, which necessitated organizing in a separate social structure. The commercial environment provided each founder with added flexibility to pursue their goals, access to commercial funds, and customers who could readily benefit from their knowledge-based offerings.

Neither of these two companies organized as speculative long-term R&D projects. Both Beta and Echo organized as new ventures with products and services that they could immediately market for revenue. As such, the strategies of both companies incorporated aspects of exploitation, which enabled them to market their knowledge-based resources in short-term time frames. However both companies balanced these exploitation strategic aspects with long-term exploratory elements that would enable them to diversify their businesses with new knowledge over a longer time frame. Beta and Echo differed with respect to their strategies of exploration. Beta's exploration strategy was more established and based on a model of transparency and widespread collaboration, while Echo exhibited a more nascent exploration strategy that was contingent upon the strengthening of intellectual property protections.

The University of the Southern Hemisphere and the broader academic community played varying roles in the context of both companies. For both Beta and Echo, technology transfer channels were not involved in the launching of each venture. Both companies undertook the exploitation aspects of their respective strategies independent of any university involvement. The university was not involved in helping either company market their respective products or services, and neither company appeared to seek any such assistance from the university. Echo had the resources of University Enterprises at its disposal, while Beta did not. Yet both companies "went at it alone" by leveraging their otherwise extensive networks of business and investment contacts. Despite the university's lack of involvement of the exploitation side, academic connections mattered more to the exploratory aspects of each company's strategy. With a well-established research program, Beta heavily relied on its academic ties for attracting local student researchers and for engaging on a global level with specific experts. Likewise, Echo was beginning to explore potential collaborative ties with local universities in order to enhance its own internal R&D for the purposes of developing adjacent opportunities for its core technology. The University of the Southern Hemisphere did not appear to hold an exclusive relationship with either company, as each company considered other universities as potential collaborators.

Academic legitimacy was a common factor for both companies, but its dynamic differed in each case. The underlying knowledge base of both Beta and Echo was rooted in academic knowledge. Therefore, the citation of the University of the Southern Hemisphere as an affiliation or the citation of related research that ascertains the credibility of each company's business model were important marketing aspects and enabled the companies to establish themselves as legitimate enterprises. Any new venture must establish the credibility of its product or service. For an academic spin-off company, the validation of knowledge by peers in the field of one's venture is a mechanism for establishing some degree of credibility for an idea, while the securing of investors and intellectual property protections is a mechanism for establishing the credibility of the commercial viability of the idea. Academic legitimacy was an ongoing concern for Beta's value proposition because its cognitive testing product was routinely used in clinical trials. For Echo, the establishment of academic legitimacy was important at the outset of the venture, but its ongoing importance seemed to diminish over time. Also, the source of academic legitimacy was quite variable. Because of Beta's ongoing renewal of academic legitimacy, the company seemed to establish a reputation across a wide network of academic colleagues. The University of the Southern Hemisphere was not the pivot point of the company's legitimacy.

For both companies, the value of knowledge creation is determined by two criteria. *Is it valid,* and *does it yield something that works?* These two academic spin-off companies organized and went to market with products and services. Before doing so, the founders of each company tacitly and affirmatively answered each question.

Chapter 8 – Conclusion

Chapter overview

This chapter summarizes key lessons from this dissertation with theoretical summaries and directions for future research. The first section of this chapter revisits the essence of *knowledge creation,* which addresses the main research question. I will revisit the constructivist philosophy of knowledge as a central tenet for understanding knowledge creation in academic spin-off companies. I will illustrate how evidence of knowledge creation reveals itself throughout the research process. Included in this section are various directions for future research around knowledge creation.

The second section of this chapter addresses a key insight around the meaning of *projects* and *practices*. My dissertation study was designed from an organizational level of analysis and from the perspective of the spin-off company. Throughout my dissertation, I explored various archetypes of organizing, which enabled me to make meaningful distinctions among the six companies in my sample. I revisit these archetypes and explore directions for future research from the level of analysis of *projects* and *practices.* This reframing affords me the opportunity to develop additional insights about my sample companies and explore various aspects of organizational patterns. In this section I offer a revised conceptual framework, which factors in these new reflections about the projects and practices.

In the third section, I consider my research against the broader backdrop of academic research commercialization in the life sciences. Specifically, I consider the arguments of Pisano (2010, 2006), which suggest that the business of science (life sciences in particular) has struggled at profitability and overarching success. I use these arguments as a lens through which to reflect on the inter-institutional nature of academic spin-off companies and their relationships with the academic community. I argue that the university technology transfer function should evolve to address the systemic shortcomings around life sciences and that university technology transfer could assume more of a knowledge orchestration role in the midst of broader collaborative innovation networks. These arguments address the sub-question of this dissertation, what roles do universities play in the creation of knowledge by academic spin-off companies?

I conclude this final chapter with other directions for future research that stem from various insights that I gained from this endeavour. In particular, I reflect on the meaning of doing "good science" for the enrichment of society and the ways in which academic spin-off companies embody the passions of the academic scientists behind them. I also reflect on the geography of innovation and the extent to which *place* and *space* matter to the study of knowledge and innovation.

Revisiting knowledge creation

My dissertation began with a key research question – how do academic spin-off companies create knowledge? An elaboration of *knowledge creation,* therefore directed my attention throughout this process. In the literature review from earlier in this dissertation, I argued that knowledge creation is an iterative cycle of questioning and answering. We update and refine what we know about the world through the process of creating solutions and then critiquing and modifying them (Lee and Cole, 2003). Individuals engage in this iterative cycle, and organizations assimilate individuals into a social structure and amplify knowledge creation at a collective level (Nonaka, von Krogh, and Voelpel, 2006). Thus, knowledge is created when individuals or organizations offer updated conclusions (as expressed through such means as abstract ideas, concrete solutions, or patterns of behavior) about the world.

The constructivist perspective of knowledge creation

Among the key insights in my dissertation, knowledge creation in the context of academic spin-off companies and research commercialization exemplifies the constructivist epistemology. Knorr-Cetina (1981) writes, "The "products of science are contextually specific constructions, which bear the mark of the situational contingency and interest structure of the process by which they are generated, and which cannot be adequately understood without an analysis of their construction" (p. 5). With respect to the notion of "contextually specific constructions," knowledge creation in the social structure of an academic spin-off company differs from that of a university in that it is more open ended in the latter than it is in the former. Colloquially, universities pursue the creation of knowledge for its own sake, while businesses pursue the creation of knowledge in order to address a specific "real world" issue and produce a marketable product or solution. With respect to the notion of "situational contingency and interest structure," knowledge created in the context of an academic spin-off company bears the mark of the vested interests of their respective investors and customers, the situational contingencies associated with the funding or de-funding of R&D projects, and the normative standards of academic collaborators or peer reviewers whose actions lend credibility to company projects.

Many of the companies in my sample engaged with the University of the Southern Hemisphere and other universities under contract for specific collaborative research projects that supported overall company goals. However, in addition to engaging university researchers, some academic spin-off companies work with other stakeholders. Beta is a particularly good example of how a company engages with its customers (in this case, large pharmaceutical companies) in order to strengthen its exploratory research and, ultimately, its efforts at creating knowledge for practical ends. This is consistent with Van de Ven's (2007) notion of *engaged scholarship,* whereby researchers collaborate with stakeholders to use research for achieving practical goals that are situationally constructed. Popper (1972) writes that knowledge grows and is created by scientists who confront problems and attempt to solve them by re-evaluating and updating existing theories. Again, this notion of knowledge creation is driven by the situation-at-hand and the intellectual reactions to it, which is consistent with the practical nature of academic spin-off companies.

Evidence of knowledge creation

Throughout my study, I sought the verisimilitude of knowledge creation. How do I know it when I see it? Academic conference presentations and publications offer tangible evidence of the iterative cycle of questioning and answering, as knowledge is created and disseminated in these explicit, codified forms. Yet the situational contingency of such dissemination is usually marked by a need for funds in support of a spin-off company's program of R&D. Thus, these forms of knowledge dissemination follow careful negotiations of the scientific terrain in order to ensure dissemination through the highest quality channels. Scientists looking to raise additional R&D funds and signal the credibility of their work will often seek publication in the "best" journals or deliver presentations at the "most prestigious" conferences.

Evidence of knowledge creation is also found in routines. Various forms of scientific practice were evident throughout this study that represent the iterations within the context of creating knowledge. Beta Health Services maintained an extensive student fellowship program that involved continuous engagement with groups of students on various research projects of strategic importance to the company's knowledge base around human cognition. Alpha Pharmaceuticals and Foxtrot Pharmaceuticals demonstrated various processes for developing compounds that would ultimately contribute to each company's library of compounds to be developed as possible drug treatments. Such routines would also include the sharing of information such as test results between labs, which would subsequently lead to new insights among those involved in such collaborative practice.

Coordination was another interesting factor in the process of knowledge creation. In loosely coupled scientific practice that underlies virtual collaboration within some of my sample companies, coordination became the means by which order could be appropriated from disorder (Patriotta, 2003) and by which meaning could be constructed by connecting participants' scattered, but related, insights. Coordination can also be considered in relation to Latour's (1999, 1987) concept of *translation* in which the interests of people working in similar but parallel trajectories are combined to form a single shared goal.

For example, in the case of Delta Pharmaceuticals, an investor's suspension of funding of the company's HIV drug development project nearly derailed the company because it halted the actual work that scientists were doing in their lab. Consequently a coordinating entity became necessary in order to cultivate new interest in Delta's project and attract funding to sustain it. This coordinating entity, BioMedicine Services (BMS), successfully attracted funding, but the interest structure of the new funding source necessitated the participation of other scientists with specific expertise as a condition of funding the Delta project. BMS organized a team of loosely coupled scientists and other drug development experts from around the world – who otherwise have no order among them – and coordinated their activities in an orderly way. By coordinating this loosely coupled team and creating order among team members, BMS amplified the knowledge of these individuals within Delta's organizational structure.

In writing about translation, Latour (1987) gives the example of a rich businessman who wishes to fund a pet project that enrols scientists in the search for the specific mental neurons for inductive and deductive reasoning. Scientists are skeptical of this rich man's goal, so they persuade the rich man to invest in *their research*. But Latour writes that one way the two parties could reconcile is through a translation of interests. "You cannot reach your goal straight away, but if you come my way, you would reach it *faster,* it would be a short cut...A little detour through *their* neurology is necessary for a few years before the neurons of induction and deduction, which he is aiming at, are evenetually discovered" (Latour, 1987, p. 111-112). This scenario mirrors Opal's HIV drug development project. The work of the original scientists was defunded, but their goal of developing their findings into an HIV treatment remained. BMS shopped the project and the goal to a variety of investors, and the willing investor set parameters that necessitated a detour from the original founding scientific team to a new, loosely coupled project team that BMS would coordinate. Thus, BMS translated the Opal project from one group of scientists to another group. Given that investor funding for key R&D projects is an important aspect in the life of many academic spin-off companies, translation of research interests among stakeholders and the corresponding enrollment of researchers into projects is a realistic course of action in knowledge creation.

Coordination plays another role in the appropriation of order. When unforseen circumstances (i.e. a loss of funding or issues with the efficacy of a drug or technology) disrupt a project, the integrity of existing work and the value of knowledge that has been created in the course of the project may be questioned or challenged. Responses need to be orchestrated in the face of a shifting context, and knowledge about how to address these disruptions must be coordinated within the responsible social structure. Coordination offers another interesting area for future research on knowledge creation because it represents an increasingly important function, as distributed practice across globally dispersed networks consume a greater share of collaborative innovation efforts. Even if disruptions are an expected aspect in the course of a large-scale project, they require increasingly complex responses when participants are globally dispersed. Coordination also represents an interesting area for future research about confronting unexpected disruptions to iterative cycles of knowledge creation and the organizational responses to those disruptions (see Weick and Sutcliffe, 2001).

Understanding academic spin-off companies from the levels of projects and practice

One of the overarching insights stemming from this dissertation research concerns knowledge creation and levels of analysis. In the course of research design, I considered several possible levels of analysis for this study. I considered the university's role and studying spin-off companies from the perspective of the university and its technology transfer office. I also considered an individual level of analysis and studying spin-off companies from the level of the individual actors in the process. Ultimately I chose to take the perspective of the spin-off company and consider the ways in which commercialization and knowledge creation efforts are affected by its relationship with the academic community. I selected the latter as my level of analysis because of its novelty and for the opportunity to study broader issues of academic research commercialization from an "outside-in" perspective (academic research commercialization from the institutional perspective of the company, looking “in” toward the academic community).

‘Projects’ as a level of analysis

After conducting this study and reflecting on the findings, I believe that future research about academic spin-off companies (and possibly academic research commercialization as a meta-level topic) should be approached from the level of the project. This conclusion stems from a reconsideration of the “ideal” archetypes for knowledge creation.

The “project” level of analysis was one that I did not consider when designing my study and actually represents a novel approach to the study of academic research commercialization and possibly the broader study of entrepreneurial businesses (whether or not the businesses are academic in nature). The grouping of the six companies in my sample into three archetypes enabled me to see a broader pattern of organization around projects. The “virtual” companies in my sample as well as the “communities of practice” were organized around specific, long-term, exploratory projects. The “hierarchical” companies in my sample divided their projects into shorter-term knowledge exploitation as well as longer-term knowledge exploration efforts. Hence, projects may offer a meaningful lens through which the social structure of knowledge creation may be observed, and organizational archetypes may be best understood.

In my original conceptual framework (Figure 2.1, p. 75), I argue that knowledge is created through recognition of limitations to existing knowledge and that the subsequent setting of goals and determination of strategies structures organized practice to achieve these stated goals. An interesting characteristic of projects is that, by definition, they have goals that are meant to address something specific, which direct people's work. The tracking of the success of a project involves determining the extent to which it moves closer to addressing its stated goals. Many of the companies in my sample were organized around single projects, which means that these companies live and die by their projects. If a project changes hands or is de-funded, the entire company may be consequently reorganized and reconfigured.

The organizational structure of many academic spin-off companies is determined by the characteristics and scope of their respective projects. In some cases, projects may remain constant, while the organizational structure of the academic spin-off company varies over time. This was the case with Charlie Medical Technologies and Delta Pharmaceuticals whose projects were sustained over time, while the constellation of people working on these projects reorganized and reconfigured.

In other cases, projects and the company associated with them may both remain constant. This has been the case with Alpha Pharmaceuticals and Foxtrot Pharmaceuticals. Many of the same core people have remained involved in each company's respective projects over time, but some project collaborators have come and gone as project needs evolve. With Alpha, the core project team has remained constant, but the locus of the project has shifted from the United States to Australia, shifting from one lab to another. Additionally, various collaborators with the core community have participated and moved on. For example, clinical trial stages have occurred at various research sites under the direction of various project collaborators. Upon completion of the work in these stages, the collaborators no longer need to actively participate in the company project.

The hierarchical companies in my sample – Beta Health Services and Echo Technology Solutions – are organized to exploit existing knowledge resources, but they balance this strategy by engaging in multiple exploratory projects to create new knowledge. Beta engages in a variety of exploratory projects through its student fellowship program and through a variety of collaborative relationships with multiple academic partners. Echo has recently engaged in projects to explore new applications of its existing technological platform. In companies whose strategies are purely exploratory in nature, organizational structure follows the nature of these exploratory projects. Yet in the case of these two hierarchical companies, exploratory knowledge creating projects flow from an organizational structure that is already defined by its knowledge exploitation strategy. Thus, the company remains an appropriate level of analysis when dealing with hierarchical organizations, but projects provide a richer analytical perspective that enables a researcher of knowledge creation to further discern more meaningful distinctions among companies of varying structure, goals, and strategies.

Reflections on the meaning of 'practice'

Projects also enable us to observe *practices* at an appropriate level of analysis because they reveal different patterns of knowledge creation. Knowledge creation is embedded in *practice*. That is, scientists and researchers with deep domain expertise and the interest and ability to stay abreast with existing knowledge and participate in critical discourse around their area of expertise are *practicing* their respective crafts and engaging with their respective professions. This reflection on practice stems from a further consideration of the *community of practice* archetype in my initial framework and the meaning that can be applied to the broader understanding of the social structure of knowledge creation.

Communities of practice are social learning systems embedded within superordinate systems, which are constellations of these communities (Wenger, 2000). In the examples of Alpha Pharmaceuticals and Foxtrot Pharmaceuticals, core company scientists are organized as communities of practice focused on their respective drug development projects. Yet these scientists belong to a variety of superordinate systems – including the larger organization of the University of the Southern Hemisphere and the organization of their respective academic departments. Brown and Duguid (2001) suggest that those who study communities of practice should not lose sight of the meaning of *practice*. Specifically, the knowledge that an individual constructs within an organization and which is concurrently amplified through organizational structure is expressed through the specific practice in which they engage. For example, chemists at Foxtrot pharmaceuticals make compounds, and they subsequently transfer those compounds to medical scientists within the company project team who conduct further proof-of-concept studies in animal models. Both the chemists and the medical researchers are engaged in practice, but the structure of the company connects the practices of these scientists and amplifies their efforts as collective knowledge that addresses the company's goals. Similarly, Beta Health Services engages students in an extensive fellowship program. Students individually engage in the practice of research, but Beta collectively amplifies the work of these individual students as cumulative knowledge that contributes to the company's larger efforts around human cognition.

Additionally, Duguid (2005) reminds us, practice occurs at various levels of interaction. So while scientists at Alpha Pharmaceuticals and Foxtrot Pharmaceuticals practice in proximity to one another as members of close-knit communities, scientists at Charlie Medical Technologies and Delta Pharmaceuticals practice as members of extended networks whose loosely coupled interactions are coordinated by project managers.

The original concept of a community of practice (Wenger, 2000; Wenger and Snyder, 2000; Lave and Wenger, 1991) is comprised of interactions among individuals in proximity to one another and collaboratively working on specific projects. These individuals share common epistemic beliefs. They self-organize and self-regulate around a "joint enterprise" based on shared competence; they establish norms and relationships of "mutuality"; and they produce a "shared repeortoire of communal resources" such as routines, artifacts, tools, etc. (Wenger, 2000, p. 229).

Duguid (2005) suggests that some shared practice occurs without close personal interaction. He argues that *networks of practice* exist when loosely coupled individuals interact with one another in joint projects and tasks but otherwise do not ever meet. He gives the example of a student who is socialized into an academic discipline and who eventually practices that discipline but never personally interacts with many similar professionals who comprise his or her extended professional network.

Shared practices may occur across disciplinary boundaries. An individual who is socialized into a specific discipline may develop expertise that is valuable to others engaged in projects that span disciplinary boundaries. Wenger's (2000) definition of a community of practice includes the concept of engaging in a *joint enterprise,* which may include interdisciplinary endeavours that seek these individuals. Networks of practice may also involve the same level of shared interdisciplinary practices but whose members are not working in close proximity.

Academic spin-off companies are organizations whose members practice their academic disciplines in contexts that prioritize applications to practical problems. When organizing my data and looking for meaningful distinctions among the six companies in my sample, I arrived at three categories of organizational structure based on the coupling of organizational actors that differentiate among the nature of practice within these companies. Thus, the distinctions among practices across the six sample companies and the extent to which these practices underlie company projects offer a lens through which to study academic spin-off companies.

Linking projects and practices in a revised conceptual framework

In this section I offer a revised conceptual framework (Figure 8.1). This revision is based on the initial framework that I proposed in Chapter two (Figure 2.1), but it now incorporates projects and practices as elements in the knowledge creation process. Additional research on academic spin-off companies – using *projects* as the level of analysis – could further refine this framework while offering updated conclusions about the nature of practices.

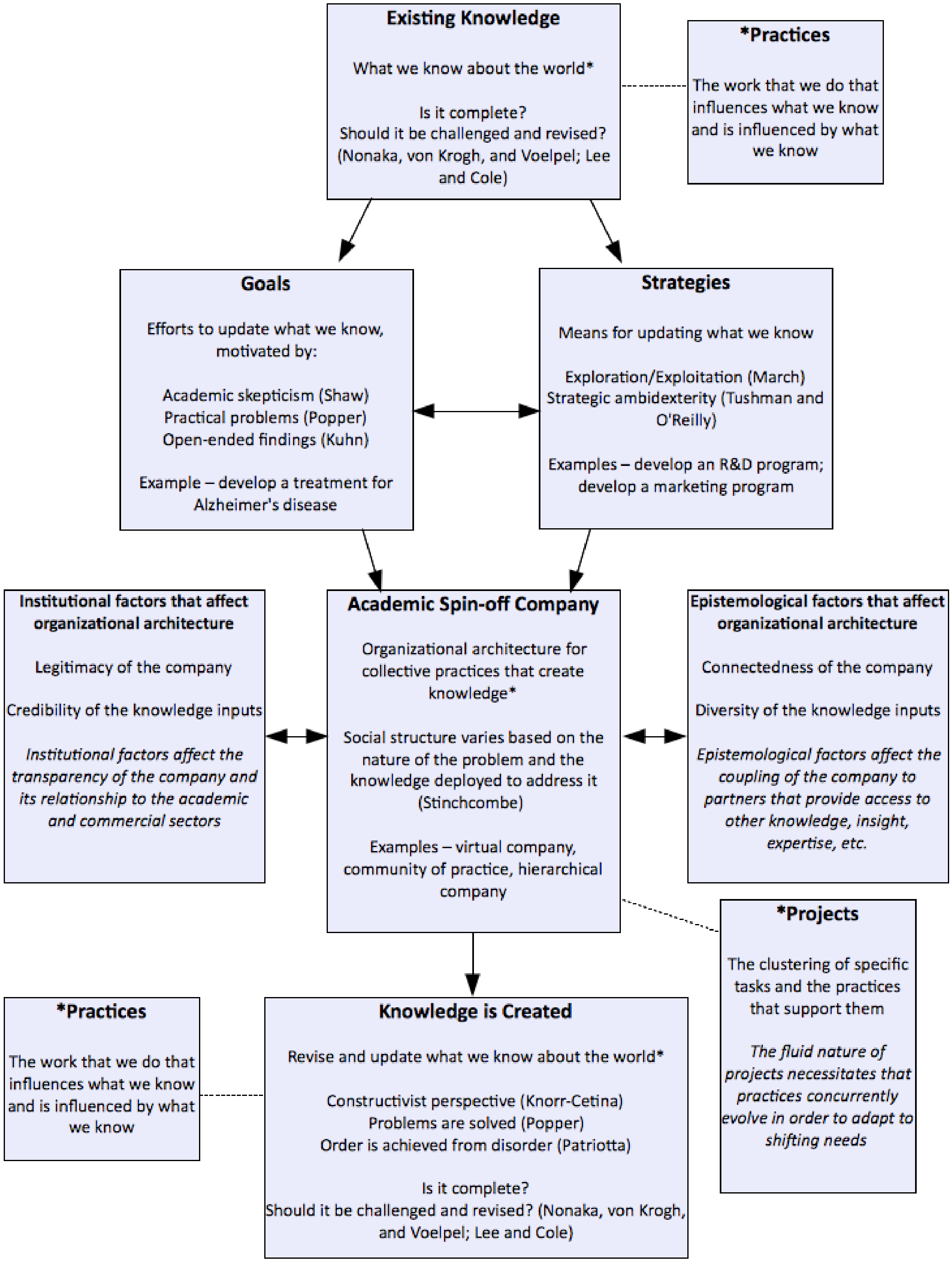

Figure 8.1 – Revised conceptual framework

The labelling of organizational archetypes in the present study is a means of making meaningful distinctions among the companies in my sample. However, these archetypes are fluid and appear to represent a snapshot view of the social structure of company projects and practices at a given period of time. Archetypes are not deterministic. Individuals do not set out to establish virtual companies or communities of practice.

For example, the two virtual companies in my sample – Charlie Medical Technologies and Delta Pharmaceuticals – did not originate as virtual companies. Much like the community of practice companies, Charlie Medical Technologies originated as a self-organized group of academic scientists who shared a passion for the development of an idea about the transplant of smooth muscle tissue (into a replacement sphincter for continence control). Likewise, Delta Pharmaceuticals originated as a discovery in a university research lab, which evolved into an HIV drug development project that encompassed the entire lab. The evolution from tight-knit proximal groups of scientists to virtual companies came about as the project goals moved to drug device development that required a form of specialized practice that was not available within the founding teams. In other words, these two companies evolved from tightly coupled communities of practice that could be coordinated within the lab environment to loosely coupled networks of practice that required coordination of geographically dispersed experts.

These study findings support an important revision of my conceptual framework. Academic spin-off companies are comprised of one or multiple projects. The clustering of specific tasks and corresponding practices of individuals underlie these projects. The fluid nature of projects necessitates that practices concurrently evolve in order to adapt to the shifting needs and demands of projects as they advance toward achieving a company's stated goal.

In my original conceptual framework, I propose that epistemological and institutional factors influence the organizational architecture of academic spin-off companies. Epistemological factors relate to partnering between a company and other individuals or organizations that offer requisite knowledge and expertise that support the goals and strategies of the company. These factors coincide with a spin-off company's overall level of connectedness. Institutional factors relate to ways in which a company builds credibility around its knowledge base and signals its legitimacy to stakeholders. These factors correspond with the overall transparency of a spin-off company's knowledge base and its relationship to both the academic and commercial sectors.

The study of an academic spin-off company from the level of projects necessitates a look at the ways in which epistemological and institutional factors impact the nature of projects. For example, Beta Health Services routinely engages in a variety of research projects around human cognition, which reinforces the company's expertise as a provider of cognition services and strengthens the applicability of its core cognitive test. Some of these projects are field based in that researchers engage in studies of cognition in a particular sample population. Field based projects often require collaboration with experts, which epistemologically diversify the project team. Because academic credibility is important to Beta, projects are structured in order to provide researchers with opportunities to publish their findings.

Beta Health Services was a unique company within my sample in that it was the only company that extensively involved students. Students broadened Beta's skill set with epistemological diversity. The company's transparency gave students an opportunity to engage in projects and publish their findings. In contrast, other companies were less willing or unwilling to involve student researchers. Such unwillingness reflects commercial institutional factors around intellectual property protections. When Delta Pharmaceuticals was initially founded, it was structured as a project within a single university research lab, which benefited from the intellectual diversity of students. However the institutional constraints of intellectual property protections necessitated that students would have to embargo for one year any research publications stemming from their efforts on the project. While Delta ultimately provided opportunities for students to participate in a project and publish, other companies (for example, Alpha Pharmaceuticals and Charlie Medical Technologies) largely disallow student participation because of concerns over intellectual property. Such policies constrain the nature of projects by restricting participation by students and others who might otherwise add value through contributions of their practice. Thus, a consideration of companies from the level of their projects provides a level of detail about specific constraints to practice that might not otherwise be evident.

The perspective of projects and practice offers opportunities for future research. Additional research could elaborate the propsed framework to the extent that epistemological and institutional factors affect the nature of practice and the evolution of projects that comprise academic spin-off companies. Future research could be designed such that it focuses on academic spin-off companies that specifically operate multiple projects and study these companies from the perspective of these projects. Another possible opportunity is to study academic spin-off companies that "failed" – meaning that the corporate entity ceased to operate or that corporate funding for projects was exhausted. The projects behind such "failed" companies may reveal a different story about the nature of practice and the extent to which knowledge was created in the course of these projects.

Academic research commercialization and life sciences research

A tangential group of conclusions that stems from this dissertation research clusters around the topic of academic research commercialization in the life sciences. I elected to control my study by focusing on companies from a common industrial context – the life sciences. Most of the six companies in my sample can be categorized as life sciences to the extent that they are engaged in drug development projects or medical device development projects. One of my companies – Echo Technology Solutions – is not exclusively a life sciences company, but one of the core applications of the company's technology is medical imaging. The selection of these companies was designed to offer a balance of industry control with a sufficient level of variation in order to arrive at interesting conclusions. Because of this concentration in the life sciences, my dissertation offers some potentially useful insights into issues facing the life sciences.

Pisano (2010, 2006) has argued that the life sciences represent a novel organizational form of "science business" as characterized by the strategic challenges of exploration and exploitation (March, 1991). He contrasts traditional high-tech industries with the life sciences in a notable way. While most high-tech industries and their firms are organized to exploit existing knowledge created by scientists applying that knowledge to new technologies, life sciences firms usually face an exploration challenge in that the basic scientific knowledge that offers hope for addressing large-scale challenges is often underdeveloped and requires extensive research before it can be developed and exploited as new technology, drugs, solutions, etc. Therefore, many life sciences companies remain unprofitable and cash-flow negative, which raises fundamental questions about the viability of the industry as a whole.

My dissertation addresses elements of organizational variation among academic spin-off companies in the life sciences, but the study's emphasis on knowledge creation particularly offers some fresh insights that address some of Pisano's key issues with the life sciences industry. In this section, I use Pisano's arguments to frame some reflections about academic research commercialization and collaborative innovation in general. Also in these sub-sections, I will reflect about ways in which university technology transfer efforts can be redirected in order to address these issues.

Evaluating the success of academic spin-off companies

One of the questions that lingered in my mind throughout the course of my study was, how do I evaluate the success of these academic spin-off companies? Most of the companies in my sample – at the time of the study – were unprofitable. Profit is an important metric for determining the success of companies, but it is not the only metric. Additionally, expectations for profitability in early stage, entrepreneurial companies, like those in my sample, are low. This is an especially problematic matter in the life sciences industry. Nevertheless, the companies in my sample demonstrated the ability to attract investor dollars in support of their respective projects. I devoted considerable attention throughout this dissertation to the concept of legitimacy, and I argued that establishing and signalling legitimacy is an important element of the success of academic spin-off companies. That is academic credibility is an important factor in determining the value of a promising, but unprofitable, program of research and development that demonstrates the potential for a breakthrough innovation.

Academic research and business performance are dominated by two separate criteria for success, as Pisano (2010) notes, "In science, score is kept by peer review and grant givers, and measured ultimately by reputation; in business, score is kept by capital markets and measured by profitability" (p. 470). This is consistent with the inter-institutional dynamic that my dissertation research uncovered with respect to competing factors of legitimacy. Pisano offers three directions for achieving success in the life sciences industry – managing risk and rewarding risk taking; integrating the skills and capabilities that reside in a range of disciplines and functions; and advancing critical knowledge at the organizational and industry levels. I will address these three directions.

Managing risk

One of the issues of the life sciences industry that Pisano raises is that most companies are islands of specialized expertise that monopolize knowledge as intellectual property. Conventional wisdom suggests that the ownership of intellectual property is a hedge against the risk of a project with an uncertain future because it represents exclusive ownership rights to knowledge that could be sold or licensed for revenue.

The protection of knowledge as intellectual property was a theme among the companies in my sample. This theme expressed itself in multiple ways. First, some companies disseminate few, if any, research findings. Second, some companies embargo research findings for a fixed period of time until appropriate intellectual property protections are secured. Third, some companies are selective about disseminating research findings by only disseminating "significant" results that would attract the attention of high calibre research journals. Many companies did recognize that dissemination of knowledge was beneficial both as a way to establish credibility and overall legitimacy as well as a way to market their businesses. Of course marketing strategy varies. For a company with a largely exploratory strategy, marketing is a mechanism for generating additional investment dollars. For a company with an exploitation strategy, marketing is a mechanism for attracting customers.

My research suggests that the recognition of the importance of academic legitimacy by a spin-off company will balance against overly restrictive intellectual property concerns and loosen knowledge flow by enabling more instances of research dissemination. Some organizations are using other solutions to address this issue. *The New York Times* recently (Kolata, 2010, August 12) reported about the Alzheimer's Disease Neuroimaging Institute (ADNI). ADNI is an example of an organization that plays the role of knowledge broker with the overarching goal of accelerating research into the root causes of Alzheimer's disease by expanding access to shared knowledge while addressing ways to manage intellectual property protections among participants involved in Alzheimer's research.

Interestingly, this model of knowledge brokerage may be a role universities can more effectively play. University technology transfer is often rooted in "doing what is best for the technology," which sometimes leads to a solution chasing a problem in a "garbage can" sort of way (see Cohen, March, and Olsen, 1972). By shifting the focus from the solution to the problem, or challenge, technology transfer as a profession can assimilate and organize knowledge from the perspective of alignment between problems and solutions. Technology transfer contributes little to the bottom lines of many universities, so this refocus would not necessarily disrupt an otherwise attractive university operation and may instead generate more opportunities for raising research dollars.

I have argued that academic research commercialization efforts lead to knowledge creation by challenging, critiquing, and updating existing knowledge.

Ultimately, the generative qualities of knowledge creation – rather than the transactional qualities of technology transfer – may be a more appropriate focus for the broader category of academic research commercialization. By de-emphasizing technology transfer and the associated issues of intellectual property and refocusing on knowledge creation, the risk criteria for academic spin-off companies change. Instead of simply asking, “How can we protect our intellectual property?” academic spin-off companies might want to consider, “How can we gain access to more relevant knowledge and what are the drawbacks to not participating in more open flows of knowledge?”

Integrating skills and capabilities

Pisano argues that new drug R&D projects are not easily broken into pieces. The exploratory and ambiguous nature of projects necessitates flexibility with respect to project timelines, involvement by experts of diverse disciplinary backgrounds, and coordination of knowledge flow.

Life sciences R&D is not easily broken into pieces because it is a generative process. Interdisciplinary work requires a certain level of knowledge transparency, which may compete with the need to protect knowledge as intellectual property. But knowledge transparency and protection can be balanced, and interdisciplinary expertise can be managed by rethinking the life sciences through various models of collaborative innovation. Gloor and Cooper (2007) write about “swarm activity” within collaborative innovation networks (or COIN’s) in which loosely coupled participants focus on a shared problem for which they all share a passion. They argue that in such networks, value is realized and revenue is generated through unexpected opportunities rather than through the strict protection of intellectual property.

Coordination of such network participants remains a challenge. Additionally, anecdotal evidence from discussions with venture capital professionals during the course of my research suggests that such “open source” methods of collaboration are simply not feasible in the life sciences as long as intellectual property protection remains a core concern. Like the ADNI example and its design to accelerate knowledge creation around Alzheimer’s disease while recognizing the need to address intellectual property concerns, future models of collaborative innovation will require coordination among competing objectives.

The *idea market* approach is one that introduces new levels of coordination. In an idea market, a third party coordinates “seekers” and “solvers” of complex but practical challenges. A well known idea market is InnoCentive that scientists from Eli Lily founded in 1998, and it represents a model of brokerage of knowledge by a coordinating third party (see Tapscott and Williams, 2007).

In some ways, academic spin-off companies (especially those with a virtual structure) are idea market microcosms in which the project is a “seeker,” and its managers coordinate among loosely coupled “solvers.” Again, this reveals further opportunities for the practice of university technology transfer to operate on an idea market model. Because of a technology transfer office’s position at the center of multiple campus knowledge networks, an idea market model could mean that it connects university deep domain experts to industry in order to address practical challenges. Additionally, it could encourage the launching of new spin-off companies that are organized as interdisciplinary communities of "solvers" within the broader idea market space.

Pisano also argues that a lack of tacit knowledge transfer and mutual learning over extended periods of time are shortcomings of the current life sciences industry structure. One possible direction for future research that addresses these issues is the role of trust within networks of loosely coupled innovation. When designing my study, I was aware of the role that trust plays in knowledge transfer over extended periods of time and in relationships between parties who engage in collaborative behaviour. Trust is an interesting variable because it is often associated with close network connections and strong ties. Such social structure is often necessary for mutual learning over time, but the redundancies of such structures also can limit the level of novel insight that is often required to spark breakthrough ideas. Additionally, a deeper understanding of trust may shed new insight on the roots of intellectual property concerns in order to minimize the consequences of such concerns.

Trust in a highly embedded network of strong ties facilitates the sharing of tacit knowledge over longer periods of time (Andersson, Holm, and Johanson, 2007; Dhanaraj, et al., 2004; Reagans and McEvily, 2003). Chen and Chang (2004) argue that such networks are associated with incremental innovation because the familiarity of the relationship and its routines foster the sharing of existing information. Granovetter (2005) notes, "Because our close friends tend to move in the same circles that we do, the information they receive overlaps considerably with what we already know" (p. 34). This overlap is one of the mechanisms for the long-term transfer of tacit knowledge.

The challenge for the life sciences will be to support and sustain tight communities of practitioners who work together over extended periods of time on specific projects and develop and refine their collective knowledge. Yet coordinating entities – either idea markets, university technology transfer offices, or project managers – will have the responsibility for integrating these smaller communities into the broader industrial milieu. In other words, coordination within this industry will involve coordination among individuals and groups and connecting them to projects across network space.

Advancing critical knowledge at the organizational and industry levels

Another issue that Pisano notes is the challenge of advancing the flow of projects among companies in a cycle of continuous refinement. I have argued that a study of academic spin-off companies presents some interesting "level of analysis" challenges and that one way to refocus this area of research is to shift the focus from the company to the project. However, I should qualify this statement by separating company exploration strategies from exploitation strategies.

For companies whose strategies are mostly exploratory in nature, projects become the primary unit of analysis because it is projects that are interesting to investors. As my research demonstrates, projects evolve over time as the knowledge that is created achieves or fails to achieve specific milestones. Projects migrate among people engaged in practice, and the organizational architecture connecting these people evolves to meet the demands of the project. A project can move among different groups of people, and the "company" that owns the project acts as a coordinating mechanism that engages in project management, organization and assimilation of knowledge resources, and various "hand-offs" among participants engaged in practice (see Sharma, 2010; Weick, Sutcliffe, and Obstfeld, 2005 for related insights about organizing and "hand-offs").

This concept of inter-organizational hand-offs in knowledge-intensive endeavours represents a growing area of research. University technology transfer offices have an opportunity to engage in this coordination and hand-off role because of their position in network space that enables the connection of ideas and people – particularly in the context of university-industry networks – as well as because of their sensegiving role and their ability to communicate intelligibly across boundaries.

For academic spin-off companies engaged in the exploitation of existing knowledge, which are in a position to generate revenue from their knowledge, the company remains an appropriate level of analysis. The two companies in my sample that were organized to exploit existing knowledge resources were both hierarchies with clear divisions of labour and with clear boundaries from the university. Markets regulate these companies because they generate revenues and cash flows, the value of which is determined based on the expectation of future cash flows.

Concluding remarks

The opportunities for radical innovation in the life sciences are extraordinary. Yet achieving such levels of breakthrough innovation will require a re-imagination of the industry's structure, norms, and practices. Companies in the life sciences are a unique form of organization that often cross the institutional boundary between the academic and industrial-commercial sectors. My study of academic spin-off companies in the life sciences underscores this characteristic. One way to begin re-imagining the industrial order of the life sciences is to shift the level of analysis from that of the company to that of the project. Individual companies are often organized around one or a few key exploratory projects, yet their commercial structures often adhere to archetypes in other high technology industries where exploration and exploitation of knowledge resources is more evenly balanced.

A shift in focus from companies to projects more appropriately aligns with the knowledge creation goals of academic spin-off companies. A focus on projects can further reinvigorate university technology transfer efforts by redirecting practices to a coordination role that assimilates university knowledge resources as well as external individuals and groups with specific expertise and aligns them with seekers of solutions to practical challenges.

Other insights and directions for future research

One does not reach this point in the dissertation process and not reflect on unexpected and interesting insights (sometimes minor in the scope of the broader dissertation) and how those insights can catalyze future research. These insights do not necessarily flow from my research questions but instead stem from my genuine desire to learn from my respondents and from the fieldwork process in general.

The existential 'so what?'

A nagging question that lingered in the background of this dissertation was *why do academic scientists launch their own ventures?* A related question was *why should we care?* These are the existential questions that find their place at the completion of a dissertation when pondering the meaning of the whole experience. The answers to these questions could fill another dissertation or research study. Given that this represents an opportunity for further study, I offer these reflections in the hope of jumpstarting future conversations with others. Nevertheless, my current study offers some insight into these broader questions.

In their individual and seemingly small ways, each of the scientists interviewed for this study wanted to make the world a better place and alleviate someone's suffering. The scientists battling diseases and looking to develop drug treatments from their research obviously reflect this. The people of Echo started with an interest in the clearing of land mines out of general concern for the thousands of innocent people killed annually around the world from the remnants of war. Beta's founders recognized that better forms of cognitive testing as an aspect of major pharmaceutical clinical trials could improve the overall success of trials and help accelerate the introduction of new drug treatments. Each scientist had a passion for an idea, possessed the requisite academic training for pursuing the idea, and ultimately recognized the value of commercial mechanisms for bringing the ideas to fruition.

Each of the scientists in this study held a variety of academic affiliations when they initially pursued their respective ventures. Eight of the scientists were university faculty members. One was a doctoral student. One held a non-faculty research position. One was a post-doctoral fellow. A common denominator across their motivations for commercialization was the flexibility that a commercial environment provided for the pursuit of their ideas. In many cases, the access to commercial funding and a lack of university funding was the source of flexibility. In some cases, the goals and the means of achieving them deviated from accepted norms of academic work, and commercial space granted them flexibility to pursue their goals.

Despite these constraints, every company maintained some tie to the academic community in an effort to advance their goals. This suggests that the organization of an academic spin-off company provides its founders with the 'best of both worlds' in pursuit of their goals. The academic origins and connections to academic science distinguish these ventures from non-academically-based ventures and provide them access to desired levels of knowledge resources – whether the access is in the forms of major collaborations or minor consultation with colleagues. Yet by maintaining some degree of separation from the social structure of the academic environment, the scientists were able to avoid some of the cultural, fiscal, and bureaucratic constraints of pursuing their respective goals.

Academic spin-off companies lie at the institutional boundary between the commercial marketplace and academic community. In simple terms, this means that an academically-based venture seeks resources from both worlds in pursuit of its goals and, consequently, both worlds constrain these ventures with sometimes conflicting standards of practice. The academic community provides these companies with access to scientific expertise, research infrastructure, and other knowledge resources. The commercial marketplace provides these companies with money, access to business expertise, and access to customers and users. Conflict can arise, for example, when available money is not available for certain areas of research, or business advice around intellectual protections conflicts with academic practice of disseminating research findings.

Conflict and collaboration between agents of multiple institutions is not new and not limited to university-industry relations. Brugmann and Prahalad (2007) write about opportunities and tensions between large corporations and non-government organizations (NGO's) that have similar goals of creating value and improving the lives of people in the developing world. The authors describe the ways in which the interests and capabilities of corporations and NGO's can converge to achieve mutual goals but that such efforts require a redefinition of social contracts that govern their relationships.

Similar thinking around the convergence of multi-institutional collaboration and mutually shared goals can influence the future direction of academic research commercialization and academic entrepreneurship. This study demonstrates the ways in which academic scientists pursue commercialization as a mechanism for advancing their goals of putting their research into practice and making the world an incrementally better place. It also demonstrates that the inter-institutional differences between business and higher education complicate the pursuit of these goals. Note the contrast in the following quotes and how it illustrates these differences. The first is a quote from an academic scientist. The second is from an Australian venture capital professional.

> So various companies I've started, I've had very much the same intention, which is just to accelerate the translational part of the research from bench side to bedside. I train all my people here when they think about these things, I encourage this thinking of translational science and starting companies if you don't want to wait for people to pick up what you're doing or if you want to ensure it, start a company. But I tell them one thing, I say, 'Don't do it for the money. Don't let profit be your intention or you will fail. You have to keep your intentions pure. It has to be to help people or you will fail' (Respondent #17).

> I think we, where we come from on that is we're not philanthropic outfit looking to spread the greater good, having said that pretty much everyone on the team has spent significant time overseas and came back to Australia with a real interest in making the industry, so the venture industry but also the biotech industry succeed in Australia. We recognize that Australia has excellent basic research, has excellent clinical science, doesn't have a lot of entrepreneurial

> skills to drag technologies out of early stage at universities and be successful (Respondent #7).

The academic scientist recognizes that academic entrepreneurs should not pursue their efforts for the money alone. The venture capitalist is unapologetic about the profit motivation. These sentiments are not necessarily surprising, but they do hint at a point of convergence – that a lot of good ideas stem from university research, which require collaborative efforts for developing.

The consequence is the need for a renewed social contract between the academic and commercial world. This dissertation does not have every answer for re-writing the social contract, but its findings can drive discussions around it. It starts with the mutual recognition that universities are the centers of collaborative networks of researchers with good ideas with potential real-world benefits. It follows with an understanding of the legitimacy of ideas and the differences in the ways in which the academic community and the commercial sector accept the legitimacy of such ideas. It also follows with an understanding that knowledge is assimilated and created in order to achieve very specific goals that have practical outcomes, which coincides with Boyer's (1990) definition of the *scholarship of application*. Thus, higher education's evolving social contract and its impact on the nature of academic research commercialization remains a frontier in the scholarship of higher education and public policy.

Scientific passions and the 'soul work' of academics

One possible direction for future research is the development of a better understanding of the motivations for one's pursuit of academic commercialization from the perspective of their passions. As argued in this chapter, the scientists interviewed for this study were relatively value driven in their personal outlooks and wanted to make the world a better place through the practical goals that their respective ventures sought to address. An academic scientist could pursue their value driven intellectual passions through the university setting, but practical funding constraints may necessitate the commercialization of their efforts in order to raise money. This may lead to reluctant academic entrepreneurs. Yet some scientists may have an entrepreneurial drive to separate themselves from the university and launch their own companies out of a desire to control their work. Two scientists in my study – one each from Alpha and Foxtrot – seemed to have this natural entrepreneurial drive, as identified by other respondents. These individuals were company champions who seemed equally comfortable in both academic and business settings. One of these two scientists was a serial entrepreneur and was involved in other academic ventures that were not part of this study.

One possible motivator of academic entrepreneurship is the desire for scientists to distance themselves from that which they are most familiar in order to arouse their creative energy. This dissertation study shows evidence of many forms of interdisciplinary collaboration, and many of the respondents discussed its increasing prevalence within academic science. Collaboration with other scientists across disciplines is one way to defamiliarize oneself from one's intellectual biases, arouse creativity, and create new knowledge. As Lokke (1982) noted in a piece about sublime aesthetics, "Familiarity breeds contempt; it is the unknown which excites admiration and passion" (p. 422). To that end, entrepreneurial activities further throw people into unfamiliar territory, which forces them to act with a certain degree of creative response. An academic scientist who spends an entire career in the university environment may revel in the excitement of launching a new venture that allows him or her to further develop their ideas and renew their passions. Universities are heavily institutionalized environments, which may stimulate entrepreneurship as a way to escape the grip of seemingly inflexible norms of undesirable teaching loads, tenure review policies, disciplinary dogmatism, and publication pressures.

Existing research on creativity and workplace passion may influence future study on the motivations behind academic entrepreneurship. If people's work lives are balanced with their personal goals and connected to the efforts in support of a greater good, then organizational life blurs from life in general and is driven by self-motivation and feelings of satisfaction (Friedman, 2008; Amabile and Kramer, 2007; Amabile, Barsade, Mueller, and Staw, 2005). This creates a state in which people are energized to devote their full intellect and energy to meaningful work, which is a necessary catalyst for creativity. Creating knowledge and solving challenging and practical problems rewards people who are dedicated to pursuing work passions (Csikszentmihalyi, 1990). People who follow their passions at work can achieve happiness and become effective value creators for their organizations and their stakeholders (Thakor, 2000).

Universities are environments that nurture intellectual freedom and allow for people to pursue meaningful work. If the institutional constraints of the academic environment prohibit scientists from pursuing meaningful work, then launching their own venture may provide them with space from which to renew this meaning. In my study, many scientists maintained a blurred boundary between academic work and work that related to their companies. This has interesting implications in that the maintenance of separate – but sometimes blurred – spheres of work life provide scientists with an adequate level of freedom to pursue their independent goals through their companies while maintaining a connection to a university environment that also nurtures their sense of meaningful work.

Alternatively, academic entrepreneurship in the form of an academic spin-off company may also embody a more deliberate desire to work as an academic practitioner within extended networks of other practitioners while abandoning or distancing from the rigidites of departmental or school-based academic organization. Instead of relying on academic disciplines, departments, and schools to define the practice that one does, an academic spin-off company may in fact represent another area in the taxonomy of academic organization. In this case, the differentiating factor is that a company is a community of academic scientists with connections to other academic scientists, but it is separate from formal academic organization. Mirvis (1997) describes the phenomenon of *soul work* and argues that companies are increasingly organizing as communities that nurture collective values and goals that are achieved through the intrinsic motivation of doing good. From my sample, Beta and Echo represent this notion to the extent that they are organizationally separate from university organization, but their people maintain ties to the academic community while pursuing work that is meaningful to them. In particular, Beta maintains many academic ties and organizes its routines to mirror those of a university environment, but the company is notably separate from any university.

Academic entrepreneurship is an outgrowth of individual passions, creativity, and the desire to continuously find meaning at work. The academic community nurtures these actions by virtue of the autonomy and intellectual freedom it grants to academic professionals. Academic entrepreneurship extends these characteristics by giving academic professionals the added flexibility and creative stimulation to further pursue their goals. Future research on academic entrepreneurship could approach the subject from the perspective of individual creativity, workplace meaning, and the general field of positive organizational scholarship.

The geography of innovation

Early in my research design process, I explored some aspects of economic geography and the geography of innovation. As an American-based researcher who conducted fieldwork in Australia, the implications of such a geographic scope enabled me to reflect on macro-level collaborative work patterns across vast distances. Yet the qualitative nature of my study also enabled me to visit individual workplaces and reflect on the micro-level elements of workspace. In general, I came away with some reflections about place and space as it relates to collaborative innovation. A ripe area of future research could examine the physical pathways that people build to bridge geographic and social distance for the purpose of increasing collaboration.

The geography of universities and clusters of academic spin-off companies are interesting concepts as they relate to the situation of people and organizations relative to each other at local and extra-local levels. Because academic spin-off companies are social structures with different forms of organization, geography matters to the extent that it supports or hinders the inter-personal interaction within those structures. Existing research indicates that close, personal, and physical interaction yields rich tacit knowledge transfer, yet distant interaction yields access to otherwise unavailable but novel information. Therefore, geographic elements of collaborative relationships influence the mix of social interactions that sustain the flow of knowledge. The proximity between a spin-off company and a university matters to the extent that the local university is integral to the social structure and knowledge needs of the company. A local university can be integral, but the extra-local academic community can also be important. This study has demonstrated the ways in which knowledge can be assimilated across vast geographic distances and integrated into the rhythm of an organization. Future research could isolate the geography variable and focus on academic enterprises that are not clustered in close proximity to universities in order to better understand the mechanisms that drive their locations and their assimilations of knowledge.

On a practical level, geography and place remain important variables as it related to the building of incubators or other research parks in the vicinity of universities. Many universities peg their efforts on re-creating 'Silicon Valley" effect, but many of these efforts fall short because these variables must be considered in the greater context of social structures and patterns of behaviour.

Another interesting angle that warrants future research is the physical environment – or the architectural *space* – in which work is conducted. In my study, I encountered the Veritas centre (pseudonym) at the University of the Southern Hemisphere, which offers interesting insight into the importance of both architectural design and inter-disciplinary collaboration as factors for knowledge creation. Veritas houses scientists of various disciplinary backgrounds. It is a catalyst for the spanning of disciplines and schools of thought in anticipation of creating new ones. The open architectural design of the institute, with its emphasis on encouraging collaboration, appeared to impact the origin of Foxtrot and the subsequent collaborations of its scientists. The design appeared to matter to the formation of a community of practice. Interestingly, space did not seem to matter as much to companies such as Charlie Medical Technologies and Delta that were predominantly organized as virtual companies. While it is likely that individual workplaces of the various members of these networks or virtual organizations are important, they likely do not matter if interaction among members is not geographically localized. These are merely speculative suggestions beyond the scope of this dissertation. Yet the variables of macro-level *place* and micro-level *space* will likely be of interest to scholars wishing to pursue more specific research into the construction of research incubators or science parks in an effort to exploit academic research for the purposes of university-fueled innovation and growth.

In summary, people create knowledge, and they organize themselves in order to assimilate one another's intelligence. Physical space and geographic place affect the dynamics of human interaction, which affect organizing for knowledge creation. Future research on academic spin-off companies could explore these dynamics of space and place and the extent to which it impacts location in proximity to universities and other collaborative partners as well as the collaborative communication patterns among scientists within the social structure of a company.

Concluding remarks about the future of this research

Countless other opportunities exist for future research in the areas of academic research commercialization and spin-off companies. However there is a limit to what one can explore in a single dissertation. It is with this that I bring my dissertation to a well-deserved conclusion. On a personal level, I hope that future conversations around this topic stem from the perspective of collaborative innovation. *Collaboration* and *innovation* are often used together in discussions about the ways in which people strive to make the world a better place – both incrementally or in great stride – by collectively working in a shared manner. In the end, this is what my dissertation is really about. I learned much about life and scientific discovery during the course of this research. I applaud the many scientists who I met during the course of this project, and I am deeply grateful for the work that they do. It is my hope that this dissertation adds some fresh insight and meaning into the social world that underlies the process of disciplined discovery, and I hope that it inspires others to re-imagine new trajectories for their work and how it impacts the world that we share.

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