Department of Management and International Business

Information Acquisition in International Business: Innovation in a Small Biotechnology Firm

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Aalto University

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Abstract

This dissertation examines information acquisition for innovation in a small firm operating internationally. The topic is significant because small firms generate much of the innovation needed to keep economies vibrant. Small firms are also increasingly seeking growth in international markets. However, they face significant challenges. Key among these is information acquisition for innovation. This is particularly challenging for a small firm operating internationally because information must cross multiple organizational and national boundaries.

To gain insight into how this challenge may be met, this dissertation presents a Straussian grounded theory study of information acquisition for innovation in a small Finnish biotechnology firm. This research site is a firm that has succeeded in information acquisition for innovation although it originates from a small and distant economy and operates in an information-intensive field. Focus in the study was on activities and events dealing with information acquisition for innovation. Data on both successful and less successful innovation outcomes were collected by carrying out 40 episodic interviews with the six management team members at four points in time, thus utilizing the constant comparison technique of the grounded theory methodology. The data were analyzed using grounded theory coding and categorizing as well as Labovian narrative analysis.

Four themes emerged from the analysis of the data that deviate from the literature. One, information sources differed: universities played a much smaller role than posited in the literature, while suppliers turned out to be significant purveyors of information. Two, main challenges in information acquisition diverged: instead of tacit and complex information presenting the greatest challenges, it was the simple information about prices and end users that was most problematic to acquire. Three, it was impossible to identify a single set of successful information acquisition tactics, as they differed according to subject matter. The only exception was the importance of relevant expertise: when the management team members had the requisite expertise to identify, evaluate, and analyze information, their information acquisition activities were successful. Fourth, co-location played no role in information acquisition. Instead, the management team members used their expertise to identify and acquire the "right information" wherever in the world it was located.

These results set human expertise against routine. Despite the digital revolution and the powerful role now played by organizations, human judgment remains an indispensable tool in acquiring information for innovation. Moreover, its importance is likely to increase with growing amounts of information, from which the "right information" for innovation cannot be routinely collected and analyzed by electronic and organizational systems.

Keywords Information, knowledge, innovation, small firm, international business, biotechnology

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Helsinki 11 September 2013

Teea Vilhelmiina Mäkelä

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1 INTRODUCTION

1.1 BACKGROUND

International business, compared with domestic business, is characterized by uncertainty. This is because the international marketplace requires a firm to operate in unfamiliar environments made more complex by differences in language, culture, and institutional context (Johanson & Vahlne, 1977, 1990, 2009). Information acquisition alleviates uncertainty, making it particularly important in international business. Yet, the same reasons that make information acquisition particularly important in international business also hinder its acquisition (Johanson & Vahlne, 1977, 1990, 2009). The large multinational corporation can tackle (though not necessarily meet) the information acquisition challenge by internalizing transactions across borders (Buckley & Casson, 1976, 1986; Hennart, 1982) and by providing a community in which to exchange information internationally (Kogut & Zander, 1993). However, increasing numbers of small firms are also conducting business across national borders and these do not have recourse to such solutions (McDougall & Oviatt, 1999; Oviatt & McDougall, 1994, 2005). Yet, information acquisition is critical to these firms' operations because they rely centrally on innovation for their competitiveness in the international marketplace (Knight & Cavusgil, 2004; McDougall & Oviatt, 1999, 2000; Trott & Hartmann, 2009).

Understanding how small companies acquire information for innovation in the international marketplace is crucial in an age when developed economies are increasingly looking to small firms to drive economic growth (Audretsch, 2002, 2009; Audretsch & Thurik, 2000). Small firms that operate internationally are especially important because they generate the lion's share of all economic growth created by small companies (Autio, 2005, 2007; Autio & Hoeltzl, 2008). However, the systematic study of how small firms acquire information for innovation in the international marketplace is only beginning (Fletcher & Harris, 2012; Jones, Coviello, & Tang, 2011), although it can build on a wealth of research in innovation studies and international business studies.

1.2 RESEARCH QUESTIONS AND METHODOLOGY

The primary research question in this dissertation is *"How does a small firm acquire information for innovation in international business?"* This is addressed by putting forth two sub-questions:

(1) *How can the literature illuminate information acquisition for innovation in a small firm in international business?*

(2) *How does a small firm acquire information for innovation in international business?*

These research questions are tackled through a Straussian grounded theory (Strauss & Corbin, 1998) study that examines individual-level information acquisition for innovation in a small firm. The grounded theory methodology is well suited to a study of individual-level information acquisition because it emphasizes the analysis of action and interaction strategies of actors (Suddaby, 2006). The Straussian grounded theory methodology employs abductive reasoning of modifying and combining elements of previous knowledge and integrating them with new experience (Anderson, 1987; Paavola, 2004). This means that the researcher does not approach the empirical study *tabula rasa* but instead uses the existing literature to see what is new and interesting. However, theories are considered preliminary, open to questioning, criticizing, rejection, and reshaping upon encounter with empirical data (Flick, 2006; Kelle, 2005). Underlying this methodology is the philosophy of classical pragmatism (Corbin & Strauss, 1990; Mcdermid, 2006). This philosophical approach is based on the principle of the need for ideas to be useful, workable, and practical. Consequently, the truthfulness of theories is considered as their ability to anticipate the consequences of manipulating things in the world.

Studying individual-level information acquisition poses certain challenges to research design. Key among these is the need to control for homogeneity of context in order to be able to draw reasonable conclusions (Van de Ven & Poole, 2002). Therefore, the study was situated within a single sector and a single research site, both of which were chosen carefully in order to illuminate the phenomenon under study. The biotechnology sector was chosen because it could illustrate the central aspects of information acquisition and innovation. A small firm in Finland was selected because firms originating from a small economy such as Finland's have little choice but to engage in

international business operations. Therefore, situating the study in the biotechnology sector in a small firm in Finland could provide illustrative data concerning information acquisition for innovation in international business.

1.3 DEFINITIONS

Two central terms used in the dissertation need to be defined at the outset because they may be understood in a variety of ways. These are the terms "information" and "innovation."

Information

Information is defined for the purposes of this study in its commonsense meaning as communicated messages. More specifically, a subjective concept of information is adopted, where information is considered a sign depending on the interpretation of a cognitive agent (Capurro & Hjørland, 2005).[1] Moreover, the conventional distinction between "knowledge" and "information" is retained: knowledge is acquired information, information that has been found, selected and gathered, often from many sources, assembled into packages, and available for use.

Innovation

Innovation is defined for the purposes of this study in the economic sense as the first attempt to carry an invention (the first occurrence of a new idea) into practice (Fagerberg, 2005), this being characterized by the accomplishment of the first commercial transaction (Freeman, 1982). However, invention and innovation are not considered to stand in a linear relationship (Fagerberg, 2005; Pavitt, 2005). Moreover, the full range of innovation originally identified by Schumpeter is included here under the term "innovation": new products/services, new methods of production, new sources of supply, the exploitation of new markets, and new ways to organize business (Fagerberg, 2005).

[1] Hence, the term "information" is not used in this dissertation in the technical sense derived from Shannon's information theory (Bar-Hillel & Carnap, 1953; Shannon, [1948] 1993; Shannon & Weaver, 1949) and the "conduit theory" often associated with it (Axley, 1984; Day, 2000; Reddy, [1979] 2002).

1.4 STRUCTURE OF THE STUDY

The study is presented in four parts following this introductory chapter. The first part covers the literature review, which is composed of four sections. The first of these sections discusses the definition of biotechnology, the second reviews the main historical developments in the modern biotechnology sector, the third identifies the main characteristics of innovation in the modern biotechnology sector as put forth in the literature, and the fourth section presents the main perspectives on information acquisition in international business studies. The second part of the dissertation covers the methodology employed in the empirical study, presenting the research site, data collection, and data analysis. Following this, the third part of the dissertation presents the results from the empirical study. Finally, in the fourth part of the dissertation, the conclusions drawn from the empirical study are set out, related to the literature, and their contribution stated in terms of what is new and important.

2 LITERATURE REVIEW

The research question put forth in this chapter is "*How can the literature illuminate information acquisition for innovation in a small firm in international business?"* To answer this question, this chapter provides a review of literature that can shed light on information acquisition for innovation in a small biotechnology firm engaging in international operations, taking into account that this firm is located in the small, developed economy of Finland.

First, it is necessary to define biotechnology for the purposes of this study, which is done by briefly reviewing the main historical developments in the subject area of biotechnology. This review clarifies the distinction that is frequently made between traditional and modern biotechnology. The difference between the two can be argued to have been institutionalized to the extent that there is real divergence in innovation dynamics in traditional and modern biotechnology, even if continuities in the underlying subject matter can be said to overcome the revolutionary claims of modern biotechnology. Second, the main historical developments in modern biotechnology as an economic sector are reviewed. This is necessary because it has been noted that innovation dynamics in modern biotechnology are contextual and exhibit unique features on both sector and national levels. Hence, it is important to clarify the contexts in which theories and models of innovation in modern biotechnology have been constructed. Focus in this study is on the first-mover nations of the United States and the United Kingdom because their experiences have arguably furnished the material for the majority of theories of innovation in modern biotechnology. Moreover, these experiences have largely provided templates that have been followed when constructing a modern biotechnology sector in Finland, a context that is also briefly described.

Second, this historical review of main developments in the subject matter of biotechnology and in modern biotechnology as an economic sector is followed by a review of the main characteristics of innovation in modern biotechnology. This review is theoretical rather than historical, aiming at identifying general main characteristics of innovation in this sector. It is posited that such general main characteristics can be identified to a certain extent because the structures of modern biotechnology sectors have shown a

level of convergence as the sector has matured.[2] However, there are still differences in the national sectors and these are pointed out when relevant. It emerges from this review that information acquisition can be identified as a core activity in modern biotechnology innovation but that its characteristics notably differ between national modern biotechnology sectors. The main difference can be identified to be the extent of reliance on international sources for information acquisition. In other words, earlier theories of modern biotechnology innovation that have been constructed primarily on the basis on U.S. experiences point to strong local agglomeration tendencies of innovation, argued to be driven by the necessary information being embedded in local networks. However, later studies conducted in European modern biotechnology sectors reveal a significantly greater reliance on international information sources in these contexts. Although this phenomenon has not been analyzed in the Finnish modern biotechnology sector, studies from Sweden, which has a very similar economy to Finland, conclude that in the context of modern biotechnology innovation in a small economy, the majority of information sources are international by necessity.

Therefore, the third part of this literature review focuses on literature on information acquisition in international business operations. Literature that appears to hold potential to shed light on this phenomenon can be found in the field of international business studies, where information acquisition in the international marketplace has been studied for several decades.[3] Consequently, this literature is reviewed in the last part of the current review. Most of this literature focuses on information acquisition within multinational corporations rather than on information acquisition from external sources. Even when this literature does consider information acquisition from external sources, it largely focuses on information acquisition for internationalization rather than for innovation. However, theories on information acquisition in the international marketplace found in this literature may provide ideas regarding the dynamics of information acquisition in international business.

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[2] Although, as will be discussed, the main characteristics of innovation in modern biotechnology identified in the literature may excessively reflect the dynamics of the pharmaceuticals industry. This is because most of the existing literature has focused on applications of biotechnology to the pharmaceuticals industry, although this is only one of several application areas of biotechnology. Hence, sensitivity to possible variances in innovation dynamics between the various application areas of biotechnology needs to be maintained.

[3] International business studies literature uses both of the terms “information” and “knowledge,” but they are not consistently distinguished. Therefore, the umbrella term “information” is used for convenience when referring to the full literature of international business studies.

This literature review provides "theoretical sensitivity" to the empirical study. In line with the Straussian grounded theory methodology used in this study, the theories examined in the literature review are approached in the manner of theoretical pluralism, so that the researcher has a variety of diverging theoretical backgrounds at her/his disposal. Theories are seen as "versions of the world," considered preliminary, open to questioning, criticizing, rejection, and reshaping. Thus, use of literature does not mean settling on a favored theoretical framework prior to empirical research but rather providing the necessary material for abductive reasoning that combines something old and something unknown.

2.1 DEFINING BIOTECHNOLOGY

Biotechnology, at its simplest, is technology based on biology that harnesses cellular and biomolecular processes to develop technologies and products. At its basic, as referring to the deciphering and use of biological knowledge, biotechnology is far from being a recent development (Smith, 2004). Instead, it represents a developing and expanding series of technologies as old as civilization. Humans have been using the biological processes of micro-organisms for thousands of years, for example in brewing, baking, and dairy processing. However, while these techniques were well worked out and reproducible, their underlying biological processes were unknown, which limited the possibilities of humans to control and modify these techniques (Barnum, 2005; Smith, 2004). It was only with developments in modern science that many of these constraints started to be broken. The study of ever-smaller life forms, beginning in the 17th century with the first observations of micro-organisms (Barnum, 2005) and recently triumphing with the sequencing of the human genome (Davies, 2001; Potters, 2010), has made it possible to develop increasingly powerful techniques to control and manipulate biological processes. This has had, and continues to have, huge impact across a range of application areas that are fundamental to human existence, such as healthcare, food production, and dealing with the environment (Enzing, 2011).

Biotechnology is far from being a coherent, unified body of scientific and engineering knowledge (Smith, 2004). It covers a wide and developing range of biological, chemical, and engineering disciplines and their combinations with varying types and degrees of application to the industrial scene. Biotechnology has been applied primarily to healthcare ("red

biotechnology"), industrial processes ("white/grey biotechnology"), and agriculture and environment ("green biotechnology") (Enzing, 2011).[4] The various application areas of biotechnology exhibit different innovation dynamics (Senker, van Zwanenberg, Caloghirou, Zambarloukos, Kolisis, Enzing, et al., 2001). Moreover, there is diversity even within application areas. For example, healthcare applications of biotechnology span several industries, such as pharmaceuticals and equipment/supplies, which exhibit dissimilar innovation dynamics (Senker, van Zwanenberg, Caloghirou, Zambarloukos, Kolisis, Mangematin, et al., 2001). New biotechnology applications are also continuously emerging, adding to the diversity.

This diversity in biotechnology has resulted in a multitude of differing definitions for biotechnology, some of them wildly conflicting with each other. Indeed, some have suggested the abandonment of the term biotechnology altogether as too general and the replacement of it by the precise term of whatever specific technology or application is being used (Smith, 2004). Nonetheless, the term biotechnology has persisted. Bud (1991) suggests that the ambiguity of the term biotechnology has contributed to its staying power.[5] Therefore, this term is used here, but it is recognized that it is important to be clear about the main ways in which it can be, and has been, used in order to utilize the term with some degree of precision. This requires a brief look at the historical developments in the sciences and industries associated with biotechnology. It is particularly important to contextualize, and thus clarify, the distinction that is usually made between traditional and modern biotechnology[6] (Brink, McKelvey, & Smith, 2004). Making this distinction clear is important because most of the literature on biotechnology innovation has focused on modern biotechnology. Therefore, understanding how modern biotechnology is defined and how it differs from traditional biotechnology is crucial for making sense of the biotechnology innovation literature.

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[4] To these main categorizations are sometimes added applications of biotechnology to marine uses ("blue biotechnology") and applications of biotechnology that integrate multiple areas ("multicolored biotechnology").

[5] Bud (1991) posits that biotechnology has become a phenomenon that is not only scientific and technological but also cultural. Therefore, there is a richness of cultural material attached to the term that has been used by various protagonists even while they have been able to define the specifics of the term according to their own interests.

[6] However, even this distinction is not always clear and is used in varying ways. The way the distinction is described here may, nonetheless, be argued to be a common one.

2.1.1 Traditional Biotechnology

Traditional biotechnology is usually defined as the biotechnology techniques developed prior to the 1970s that made it possible to manipulate biological processes at the genetic level. At its broadest, traditional biotechnology can be seen to comprise all of the techniques developed by humans over thousands of years that utilize biological processes. However, the techniques used by humans over thousands of years in brewing, baking, and dairy production were artisanal practices developed through empirical observation but lacking in understanding of the underlying biological processes (Bud, 1993). The development of modern science introduced a decisive break to these ancient traditions as it made it possible to begin developing an understanding of the underlying biological processes. Therefore, the definition of traditional biotechnology is limited in this study to refer to biotechnology techniques developed with modern science from the 19th century onwards but before the genetic engineering breakthroughs of the 1970s.

Traditional biotechnology was associated primarily with the scientific fields of microbiology, biochemistry, and chemical engineering (Bud, 1993), all with roots strongly in the 19th century. Of course, the 19th century advances in these fields relied on earlier developments: improved tools of inquiry, especially the microscope, had enabled the discovery of gradually smaller life forms throughout the 17th and 18th centuries (Barnum, 2005). However, crucial for developments in what would come to be called biotechnology was the ability of scientists by the 19th century to observe the existence of micro-organisms such as fungi, protozoa, and bacteria by using increasingly powerful microscopes (Barnum, 2005). The discovery by the French chemist Louis Pasteur in the mid-19th century that micro-organisms cause fermentation made it possible, for the first time in the thousands of years that humankind had been using fermentation to produce and preserve foods, to understand how the fermentation process worked. Pasteur was also able to demonstrate that micro-organisms were responsible for the spoilage of alcohol and foodstuffs, and through his experiments encouraged the belief that there were micro-organisms in the air that could cause disease in humans. Although Pasteur was unable to prove this latter theory, the German physician Robert Koch provided the proof a few years later. The groundbreaking work by Pasteur and Koch led to a “Golden Age of Microbiology” in the late 19th century and the first decade of the 20th century (Schaechter, 2003).

The discoveries by Pasteur, Koch, and their students did not take place in an isolated scientific vacuum. Far from it, these scientific developments had great practical importance with applications to healthcare, nutrition, and the environment (Schaechter, 2003). The discovery of the microbial etiology of major infectious diseases took place during this first Golden Era of microbiology and resulted in accurate diagnoses and attempts at prevention and cure. Several vaccines used today stem from those developed by early microbiologists. Early microbiological research also made it possible to understand the cycles of matter in nature and provided a rational basis for food production and preservation. These scientific developments had significant practical applications and, in turn, were often instantiated by real-world problems and actors outside of the scientific field. An important example of this close interaction between basic science and the rest of society in the early days of biotechnology development is the fact that many of Pasteur's groundbreaking findings were made when he was studying problems plaguing the French wine industry, as commissioned by the French government (Bud, 1993; Stokes, 1997). It was during the years that Pasteur spent studying wine that he made his discovery that micro-organisms caused the spoilage of wine and subsequently developed methods for improved control of the fermentation process, thus helping to improve the competitiveness of the French wine industry (Bud, 1993).

This point of close interaction between basic science and the rest of society, in not only applying scientific discoveries to practical problems but also being instantiated by them, is important to emphasize because it provides important insights into historical innovation dynamics in biotechnology. What it reveals is that far from being the isolated basic science that biotechnology has often been portrayed as, it has instead evolved in close and iterative interaction with the rest of society. Indeed, it was in the search for a better understanding of industrial fermentation under the label "zymotechnology" that the foundations of what was to become biotechnology lay. This search involved various scientific fields ranging from microbiology to chemistry and engineering. Moreover, it took place in close interaction with industry, as zymotechnology brought together established industries with new sciences and technologies (Bud, 1992, 1993). In many ways, in this broad field of zymotechnology lay the foundations of what was to become biotechnology (Bud, 1993). As Bud put it: "the meaning of zymotechnology would be incorporated within biotechnology, and nurturing its descendant, its institutions would provide a continuity as important as the close intellectual heritage" (Bud 1993: 7). Thus, traditional biotechnology evolved from the

beginning as a multidisciplinary and interdisciplinary effort in close interaction with the rest of society, especially industry.

In the early 20th century, the introduction of biological thinking into industry, especially in the form of industrial fermentation, became increasingly common. To the earlier issues of alcohol and hygiene were added the cultivation of yeast, the disposal of sewage, and the manufacture of a variety of chemicals including organic acids such as lactic, citric, and butyric acid (Bud, 1993). A gradual shift from a narrower focus on brewing to a greater emphasis on the use of science across several industries underlay the evolution of zymotechnology into biotechnology (Bud, 1998). In 1919, the term "biotechnology" was coined in a book published by Hungarian engineer Karl Ereky in Germany, titled *Biotechnologie* (Bud, 1993; Fári & Kralovánszky, 2006). Ereky's work was widely acclaimed in Germany, with the famous microbiologist Hugo Pringsheim praising Ereky's attempt to lay the foundations of biotechnology. Ereky's work also earned recognition beyond Germany, especially in the Netherlands and in the United Kingdom, thus spreading his definition and understanding of biotechnology (Fári & Kralovánszky, 2006). Ereky's work, like that of Pasteur and Koch, was closely tied to real-world problems: Ereky used the German term "*Biotechnologie*" to describe his vision of transforming agricultural production into capitalistic industry based on science, so that "the word hunger could be cancelled from dictionaries" (Fári & Kralovánszky, 2006: 10). Notably, Ereky not only described a theoretical vision but also implemented his ideas into practice: as an example of the scientific approach to agriculture that he called *Biotechnologie*, Ereky described his own project of fattening pigs, which he called "*biotechnologische Arbeitsmachinen*," by converting scientifically calculated amounts of food input into meat output (Bud, 1993).

Ereky defined *Biotechnologie* as "all such work by which products are produced from raw materials with the aid of living organisms" (Ereky 1919, cited in Bud 1993: 27). In doing so, he laid out the basic definition of the term biotechnology that still stands. In his work, Ereky also emphasized a theme that would continue to be linked to biotechnology for the next century: that biotechnology could address fundamental human problems and herald a new era based on biological sciences connected with chemistry (Bud, 1993). Thus, although biotechnology acquired a connotation in the 1920s and 1930s that was quite different from its earlier interpretation as focusing primarily on agriculture, it continued to carry with it the earlier vision of being the way to a better future for humankind. In the 1920s and 1930s, a new attention to human health arose in Western societies, not just as a matter of the occasional

medical intervention but also as a result of an environment harmonized with the needs of society, with issues such as nutrition and non-polluting manufacturing technology becoming prominent. Biotechnology seemed to hold great promise for improving both human health and the environment. Thus, earlier interpretations and uses of biotechnology were merged with visions of a new, healthier technology (Bud, 1993). These developments reached their first zenith during World War II as advancements in biochemical engineering led to the development and mass production of microbial antibiotics, especially penicillin.

In the post-World War II era, many of the wartime developments in microbiology, chemistry, chemical engineering, and biochemical engineering continued to boost growth across a variety of industries including plastics, food, and pharmaceuticals. Biotechnology also seemed to represent an ideal alternative to various earth-destroying "neo-ologies" associated with the military-industrial complex (Bud, 1993). This resonated with several ideological and cultural forces in the 1960s and 1970s, as biotechnology was seen to hold potential to solve fundamental human problems such as hunger, disease, and resource depletion. In the 1960s, a process that grew single-cell protein on paraffin raised great expectations, especially as producing food locally by growing it on waste seemed an ideal solution to the threat of world hunger. Companies, such as BP and ICI, and governments, such as that of the Soviet Union, made considerable efforts in this field. In the 1970s, gasohol—gasoline with 10% alcohol added—raised great expectations especially in the United States, as fermenting agricultural surpluses seemed a fitting solution to the oil shortage threatened by the Iran-Iraq war. Although the idealistic visions were often dimmed by later disappointments, the new synergy at the intersection of microbiology, chemistry, chemical engineering, and biochemical engineering did seem to provide products and technologies to address many of the central needs of the time (Bud, 1993).

Developments at the intersection of microbiology, chemistry, chemical engineering, and biochemical engineering, and their applications to various industries, provided many of the institutional foundations for the so-called "biotechnology revolution" of the 1970s. These included the founding of journals and organizations that provided opportunities for microbiologists, chemists, chemical engineers, and biochemical engineers to discuss advances. It was the title of one of these—the *Journal of Microbiological and Biochemical Engineering and Technology* founded in 1958 and renamed the *Journal of Biotechnology and Bioengineering* in 1961—that launched an updated use of the term biotechnology. The term biotechnology had been

adopted into this journal title as a translation of the term "*Biotechnik*" from German. The term *Biotechnik* had come to be used in many European countries instead of Ereky's *Biotechnologie* to signify also industrial techniques, not just basic science. The focus of the term was on microbiology and "bioprocesses" in partnership with chemical engineering (Bud, 1993). Industry associations established at the time, especially the influential German chemical industry association *DECHEMA*, put forth a similar understanding of biotechnology as the integrated use of biochemistry, microbiology, and engineering sciences in order to achieve the technological application of the capacities of micro-organisms, cultured tissue cells, and parts thereof (Bud, 1993).

2.1.2 Modern Biotechnology

In the 1970s, two scientific discoveries were made that are considered to comprise the main building blocks of modern biotechnology, defined as biotechnology at the genetic engineering level that has ushered in the post-genomic era (Barnum, 2005; Brink et al., 2004). In 1973, Stanley Cohen at Stanford University and Herbert Boyer at the University of California at San Francisco developed the recombinant DNA (rDNA) technique by which a section of DNA was cut from the plasmid of an *E.coli* bacterium and transferred into the DNA of another. The recombinant DNA technique made it possible to create highly productive strains in micro-organisms and eukaryotic cells, meaning that they could be used as "biological factories" for the production of a variety of proteins, such as insulin (Glick & Pasternak, 2003). In 1975, César Milstein and Georges Köhler at the Medical Research Council Laboratory of Molecular Biology in Cambridge developed the hybridoma technique for producing monoclonal antibodies. In this technique, antibody-producing cells isolated from immunized laboratory animals are fused with cancer cells, resulting in hybridoma cells. These continue to reproduce *in vitro* like cancer cells while retaining the capacity to produce antibodies, thus allowing for the large-scale production of particular antibodies. The antibodies produced by the hybridoma are all of a single specificity and are therefore monoclonal, as opposed to polyclonal, antibodies. Monoclonal antibodies are essential to the manufacture of genetically engineered proteins. As Köhler and Milstein recognized, such cultures could be valuable for medical and industrial use (De Chadarevian, 2011).

These discoveries were grounded in molecular biology rather than in the scientific disciplines of microbiology, biochemistry, and biochemical and

chemical engineering traditionally associated with biotechnology (Bud, 1993). The significance of this was that molecular biology was a more recently institutionalized science than microbiology, biochemistry, and biochemical and chemical engineering. Emerging at the interface of biology, physics, and chemistry, it had become an institutionalized socio-historical reality in the 1930s (Abir-Am, 1987; de Chadarevian & Kamminga, 1998; Olby, 1990; Yoxen, 1982) and had made its first great scientific breakthrough in 1953 as James Watson and Francis Crick elucidated the structure of DNA (Barnum, 2005; Olby, 1994). It did not have the close links with industry that traditional biotechnology did (Bud, 1993). This meant, as will be reviewed in the following section, that the utilization of the revolutionary new techniques developed in molecular biology was accompanied by different innovation dynamics than those in traditional biotechnology. Most importantly, modern biotechnology techniques had to be transferred specifically from the realm of basic science to industry because—unlike traditional biotechnology techniques—they had not evolved in close interaction between science and industry.

The 1953 discovery of the structure of DNA by Watson and Crick is typically considered to constitute the final threshold to modern molecular biology from which the revolutionary techniques of genetic engineering and genome sequencing stem (Barnum, 2005; Gierer, 2002; Olby, 1994). The widespread acceptance among geneticists that DNA carries genetic information and the discovery of its molecular structure in 1953 opened up the possibility that genes could be manipulated at the molecular level, their function understood, and possibly corrected or controlled. Within twenty years, the possibility of working with DNA at the molecular level had been realized, with the 1973 development of the recombinant DNA technique a crucial step (Rhodes, 2010). The recombinant DNA technique gave scientists a method of participating directly in gene activity (Rhodes, 2010), which opened up a host of possibilities for developing innovation in a wide range of industries, including healthcare, agriculture and food industry, environmental protection, energy conversion, metal recovery, and chemical manufacturing (Bourgaize, Jewell, & Buiser, 2000; Ratledge & Kristiansen, 2001). The revolutionary possibilities offered by modern biotechnology have so far had the greatest impact on healthcare through the development of new diagnostics and cures (Rhodes, 2010). Prominent examples include the production of human insulin (1978), the production of human growth hormone (first cloned in 1979), and the development of gene therapies (1990).

An important recent development in modern biotechnology has been the sequencing of genomes, which has ushered in the post-genomic era whose

benefits continue to unfold. Advances in sequencing tools, and particularly the increased speed at which the information produced can be processed, made it possible to begin sequencing the human genome in 1990. The $3 billion Human Genome Project was established to carry out this task. The project was coordinated by the Department of Energy and the National Institutes of Health in the United States and the Wellcome Trust in the United Kingdom, with contributions from Japan, France, Germany, China, and other countries (HGP, 2012). The Human Genome Project had the goal of identifying all of the approximately 20,000-25,000 genes in human DNA, determining the sequences of the three billion chemical base pairs that make up human DNA, and storing this information in databases (HGP, 2012). Additionally, tools for data analysis were be improved and the related technologies transferred to the private sector while also addressing the ethical, legal, and social issues arising from the project. In 1998, the project was transformed into a race between the public sector consortium and a private firm, Celera Genomics headed by scientist Craig Venter, which sought to take over the project for business gain (Davies, 2001). However, in 2000, Venter and the public consortium reached a truce and the project remained in the public realm. In 2003, the Human Genome Project was declared complete. However, analyses of the data continue and are thought to continue for many years to come.

The Human Genome Project was projected to produce a plethora of benefits, many of which are already emerging. Moreover, it is not only the human genome that has been sequenced, but also key reference genomes such as the fruit fly, the nematode worm, and the common house mouse. Over 1,200 other genomes have been completely sequenced, most of them microbial. The sequencing and mapping of genomes have contributed to increased knowledge of the biological processes of various organisms and to better understanding of genetic functions. They provide vast amounts of data to which the tools of genetic engineering can be applied, increasing the scope of biotechnology applications. A main benefit is the enhanced understanding and improved treatment of many human diseases, but the information resulting from the Human Genome Project has many other applications as well. Among them are biofuels and other energy applications, agriculture, livestock breeding, bioprocessing, risk assessment, bioarcheology, anthropology, and better understanding of evolution (HGP, 2012). Also, the Human Genome Project has offshoots such as the Microbial Genome Program, which will increase understanding of various micro-organisms (Potters, 2010), and the Human Proteome Project, which is designed to map the entire human protein set (Legrain et al., 2011). These are already yielding benefits in

healthcare, waste treatment, and environmental management, with potential for much more as work progresses (Legrain et al., 2011; Potters, 2010).

Modern biotechnology is thus continuously evolving, in terms of both scientific development and applications across a wide range of industries. Therefore, the OECD has put forth a two-part definition of biotechnology that consists of an intentionally broad single definition and an evolving list-based definition that helps keep the single definition up-to-date as modern biotechnology continues to evolve. The broad single definition by the OECD defines biotechnology as:

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

This broad single definition is accompanied by an evolving list-based definition that supplements and clarifies the single definition (OECD, 2005b). It currently covers the following techniques:

- DNA/RNA: genomics, pharmacogenomics, gene probes, genetic engineering, DNA/RNA sequencing/synthesis/amplification, gene expression profiling, and use of antisense technology
- Proteins and other molecules: sequencing/synthesis/engineering of proteins and peptides (including large molecule hormones), improved delivery methods for large molecule drugs, proteomics, protein isolation and purification, signaling, and identification of cell receptors
- Cell and tissue culture and engineering: cell/tissue culture, tissue engineering (including tissue scaffolds and biomedical engineering), cellular fusion, vaccine/immune stimulants, and embryo manipulation
- Process biotechnology techniques: fermentation using bioreactors, bioprocessing, bioleaching, biopulping, biobleaching, biodesulphurization, bioremediation, biofiltration, and phytoremediation
- Gene and RNA vectors: gene therapy and viral vectors
- Bioinformatics: construction of databases on genomes, protein sequences, modeling complex biological processes including systems biology

- Nanobiotechnology: application of tools and processes of nanofabrication and microfabrication to build devices for studying biosystems and applications in drug delivery and diagnostics

As the OECD specifies in its work on biotechnology statistics, the area covered is wide, diverse, and evolving. There is diversity and constant development at all levels: scientific bases, techniques and technologies, and applications. The broad OECD definition of biotechnology is used in this study and the area it covers is referred to as modern biotechnology. This is justified because although continuities between traditional and modern biotechnology are clear (Hopkins, Martin, Nightingale, Kraft, & Mahdia, 2007; Nightingale & Martin, 2004), the institutional context of modern biotechnology, with developments starting in the 1970s, has differed from the institutional context of traditional biotechnology. The different institutional contexts have strongly influenced innovation dynamics, with literature widely acknowledging that the modern biotechnology sector evinces unique innovation dynamics. Therefore, it is important to make clear that the focus here is on modern biotechnology innovation, the institutional context of which is discussed next.

2.2 MAIN HISTORICAL DEVELOPMENTS IN MODERN BIOTECHNOLOGY

The preceding discussion concerning the definition of modern biotechnology has made it clear that biotechnology is not an isolated basic science but rather a series of science-based technologies that have developed in institutional contexts. Therefore, to understand innovation dynamics in modern biotechnology, it is necessary to contextualize these by reviewing the main developments of the modern biotechnology sector. This is because modern biotechnology innovation dynamics have been strongly affected by societal factors. However, because the focus in this study is on firm-level innovation dynamics, this review will only touch upon those historical developments in the societal context of modern biotechnology that may be considered to have had the greatest impact on firm-level innovation dynamics, without delving into policy discussions. The review is focused on the United States and the United Kingdom as modern biotechnology sector developments in these countries have provided templates of innovation dynamics in modern biotechnology, with efforts made to replicate them in Finland, thus affecting

the immediate context of the research site (Lemola, 2002). Finally, main developments of the modern biotechnology sector in Finland are reviewed.

2.2.1 Beginnings of Modern Biotechnology in the United States

The 1973 discovery of the recombinant DNA technique by Stanley Cohen and Herbert Boyer in California is usually considered the starting point of modern biotechnology. This discovery was indisputably highly significant scientifically, but much of the excitement around this discovery was institutionally created (Bud, 1993), which highlights the importance of viewing scientific and technological developments in biotechnology in their institutional context (Bud, 1993). In 1976, Herbert Boyer and venture capitalist Robert Swanson founded a company called Genentech to exploit the recombinant DNA technique. Genentech is typically considered the first modern biotechnology company, representing the "beginnings of (modern) biotechnology" (Hughes, 2011). In 1978, Genentech succeeded in developing a technique for microbial production of human insulin that was lucratively licensed by the pharmaceutical giant Eli Lily. This event caught the imagination of the financial community, demonstrated by the influential financial journal *The Economist* declaring that a new kind of innovative biology-based company, exemplified by Genentech, was emerging.

The fact that a new, small company such as Genentech had been able to outplay an established corporation like Eli Lilly also caught the interest of financial analyst Nelson Schneider at the high-technology investment firm E.F. Hutton (Bud, 1993). To find out more about genetic engineering, Schneider attended a meeting at London's Royal Society in January 1979 titled "*New Horizons in Industrial Microbiology*." This meeting brought together a wide range of promoters of what had long been called biotechnology in Europe—this being the integrated use of biochemistry, microbiology, and engineering to achieve the technological application of the capacities of micro-organisms, cultured tissue cells, and parts thereof. The recombinant DNA technique was discussed at the meeting, but only as the topic of the very last paper (Bud, 1998). However, Schneider returned to the United States confident in his belief that the recombinant DNA technique held great commercial potential and that his company could market the concept. To boost marketing efforts, Schneider distanced the recombinant DNA technique from traditional biotechnology techniques that were already financially mature. In doing so, he reinterpreted the message put forth at the London meeting, narrowing the definition of biotechnology to refer only to the recombinant DNA technique,

thus making it possible for him to claim that this was a completely new technology. Nonetheless, he simultaneously maintained the breadth of perception and optimism of vision long associated with biotechnology, so that while claiming that biotechnology was a brand new technology that had come into being in 1970s California, Schneider declared that it had great potential to revolutionize a wide variety of industries from pharmaceuticals to energy production and agriculture (Bud, 1998).

Schneider was remarkably successful in marketing his reinterpreted definition of biotechnology. In August 1979, he wrote a paper to investors titled "*DNA—The Genetic Revolution*," in which he described his vision of the potential of genetic engineering. According to him, genetic engineering offered great potential for both large and small companies and could affect several industries (Bud, 1993). Schneider later testified to Congress that in this area lay the roots of a new IBM. In September 1979, Schneider organized a meeting in Washington, D.C. to market his vision to institutional investors that turned out to be a huge success. Instead of the thirty participants expected, the meeting drew more than five hundred. Encouraged by the success, Schneider's company E.F. Hutton trademarked the word biotechnology and adopted it as the title of a newsletter to investors, one dealing with applied genetics rather than with biotechnology in the established, broader meaning (Bud, 1998).

In practice, modern biotechnology drew upon more than visions created in previous decades. Additional established skills were also required and were brought in from other disciplines. Indeed, it can be argued that the distinction between traditional and modern biotechnology was exaggerated because it was in the interests of many influential stakeholders, especially in the United States, to uphold the view of modern biotechnology—narrowly equated with genetic engineering—as something entirely novel and revolutionary. Scientists were keen to emphasize the novel nature of genetic engineering and the great promise inherent in it to ward off negative public opinion that could turn against their freedom to engage in this research. Politicians were enthusiastic to declare that the genetic engineering techniques were a reflection of the wisdom and success of heavy public investment in basic scientific research and would ensure U.S. industry's strategic advantage. The financial community saw genetic engineering as another great growth opportunity, as the scientific advances of the 1970s facilitated promoting biotechnology as "the next industrial revolution," resonating with other catchphrases of the time such as that of the "information age" (Bud, 1993).

The impetus in the late 1970s United States for portraying biotechnology as a completely novel development with huge promise for the

future is particularly understandable when viewed in historical context. The decade of the 1970s was the worst decade for the United States economically since the Great Depression of the 1930s. The energy crisis caused by the OPEC oil embargo adversely affected the competitiveness of traditional manufacturing industries and led to stagflation as well as a radical contraction in the stock market. At the same time, international economic competition, especially from Japan with its booming economy, was stiffening. The energy crisis, combined with growing interest in environmentalism, led to a widespread view that the technological system had become largely obsolete. In this environment, biotechnology, impregnated with cultural material constructed over a period of nearly a hundred years of being a solution to economic and technological problems as well as to human and environmental problems, appeared to be the technology of the future (Bud, 1993). Combining this breadth of vision with a portrayal of biotechnology as a novel science and technology born in the 1970s United States, it could be seen to hold potential to bring about economic and technological renewal for the nation while offering solutions to the most pressing problems of the time, such as those of environmental degradation and energy constraints.

The year 1980 was a turning point for the U.S. biotechnology sector. Four events in 1980 triggered great excitement about biotechnology as a new revolutionary industry that would revitalize the national economy. One, Genentech went to market with great success. The initial public offering marked the fastest rise of any stock in the history of the New York capital market until that point. The offering price was $35 per share but the stock was so oversubscribed that the price per share soared to more than $80 on the day of offer (Bud, 1993). This successful offering demonstrated that biotechnology companies could be sold successfully to the public even while they had negative cash flow and no products on the market (Kenney, 1998). Two, the U.S. Supreme Court ruled, in the case of Diamond v. Chakrabarty, that genetically altered life forms could be patented (Eisenberg, 2006; Kevles, 1998). This revolutionary ruling changed a long tradition in Western countries that patents could not be granted to living material.[7] Three, the Bayh-Dole Act was passed, which allowed universities and their faculty members to stake patent claims on discoveries they made through research funded by federal

[7] The view held until then had been that granting a patent to a living organism would remove from the public domain something that nature had produced and which had been intended for public use (Westerlund, 2002). The 1980 Diamond *v.* Chakrabarty judgment held that the fact that micro-organisms are alive is without legal significance for purposes of the patent law and that "manufactured" life forms could be considered as analogous to chemical compounds and thus patentable (Martinez & Guellec, 2004; Pila, 2003).

agencies instead of leaving ownership of the intellectual property with the government (Shane, 2004). Four, the Court of Appeals for the Federal Circuit (CAFC), a specialist patent court, opened. It proved receptive to maintaining the interests of patentees. In making patents easier to defend, the CAFC made them more valuable and thus increased the attraction of patenting (Macdonald, 2011). These events had a huge impact on the U.S. biotechnology sector and in the next few years, hundreds of U.S. patents were issued to "manufactured" life forms and hundreds of dedicated biotechnology firms were founded (Bud, 1993; Kenney, 1998; Pila, 2003). Biotechnology's image became one of opportunity and familiarity rather than one of danger and uncertainty (Plein, 1991). Biotechnology thus seemed, in the early 1980s United States, to characterize a nascent industry with a triumphant future (Bud, 1993).

In the next decades, vibrant conglomerations of dedicated biotechnology firms grew around the San Francisco Bay Area and Boston, boasting such commercial successes as Cetus, Genentech, and Genzyme, with many more coming up in the following years (Breznitz & Anderson, 2005). Although following the initial success of small companies, established pharmaceutical corporations moved into biotechnology in the 1980s by taking over small biotechnology companies or by setting up their own biotechnology sectors (Rhodes, 2010), the public science base continued to generate new startups (Kenney, 1998). More biotechnology clusters formed in San Diego,[8] Raleigh/Durham,[9] New York/Philadelphia,[10] Seattle,[11] Washington, D.C.,/Baltimore,[12] and Los Angeles[13] (Cortright & Mayer, 2002; Link, 2006).

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[8] San Diego has many flourishing smaller biotechnology companies as well as branches of big pharmaceutical companies, including Pfizer, Johnson & Johnson, and Novartis. Additionally, San Diego boasts many universities and research institutes, including J. Craig Venter Institute and Hubbs Sea World Research Institute.

[9] Called "The Research Triangle," the Raleigh-Durham-Chapel Hill region of North Carolina is known for acclaimed academic institutions such as Duke University and the University of North Carolina Chapel Hill, many startup companies, and major pharmaceutical companies, including Syngenta, Novartis, Pfizer, Biogen Idec, and GlaxoSmithKline.

[10] This large biotechnology cluster, sometimes referred to as "PharmCountry," stretches from Connecticut down to Philadelphia and features several universities including Princeton University, Columbia University, Yale University, and University of Pennsylvania, as well as a large amount of startups, and large pharmaceutical companies such as Bristol-Myers Squibb, Johnson and Johnson, Pfizer, and Watson Pharmaceuticals.

[11] Seattle and its surrounding area have many startups and big pharmaceutical companies such as Amgen and Bristol-Myers Squibb. Seattle is also the home of the Bill and Melinda Gates Foundation, Allen Institute for Brain Science, and Fred Hutchinson Cancer Research Center.

[12] Nicknamed "BioCapital," this area includes Delaware, Maryland, Virginia, and Washington D.C., home to George Washington University, Georgetown

Often aided by state-level policy, these clusters grew around publicly funded university research, and by the 21st century were home to 75% of the largest biotechnology firms in the United States (Link, 2006). By 2011, the U.S. biotechnology sector boasted 1,870 companies (including both public and private companies), generated nearly $60 billion in revenues, and employed nearly 100,000 employees. Even in a period of poor macro-economic performance, the U.S. biotechnology industry's revenues increased by 12% in 2011 from year before, although only after normalizing for the large acquisitions by non-biotechnology firms of three commercially leading U.S. biotechnology firms of Genzyme, Cephalon, and Talecris. The number of companies held steady and the number of employees grew by 5% on a normalized basis. Perhaps even more noteworthy is that the biotechnology sector in the United States was dynamic enough that the loss of three commercial leaders through acquisition was compensated for by a fresh crop of biotechnology companies graduating into the ranks of commercial leaders. Specifically, by 2011, the revenues of Salix Pharmaceuticals, Vertex Pharmaceuticals, and ViroPharma crossed the $500 million threshold, leaving the total number of commercial leaders (that is, companies with revenues in excess of $500 million) unchanged at sixteen. (Ernst & Young, 2012)

However, during the 21st century criticism concerning the U.S. biotechnology sector has grown. Criticism has been targeted especially at the possible long-term effects of the changes to the intellectual property regime instituted in the 1980s. Beyond ethical concerns about increased patenting in the biotechnology sector (Brody, 2006a, 2006b), critics have begun arguing that aggressive patenting hurts innovation and scientific and technological progress. These critics assert that privatizing science through patenting leads to an "anti-commons" that detracts from the open environment necessary for the advancement of science and technology (Heller & Eisenberg, 1998; Pisano, 2006; Rai & Eisenberg, 2003).[14] There is empirical support for this concern (MacKenzie, Keating, & Cambrosio, 1990; Murray & Stern, 2007) and some critics have gone as far as claiming that the privatization of science endangers the fundamental long-term health of the U.S. biotechnology sector (Pisano,

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University, Johns Hopkins University, and many other famed universities conducting biotechnology research, as well as many startups.

[13] Los Angeles is home to the largest biotechnology firm in the United States, Amgen, located in Thousand Oaks.

[14] Moreover, if firms increasingly move to use strategic patenting —that is, secondary use of patents to protect the company's reputation, to be offered as bargaining chips, to block competitors, etc.— as opposed to the primary use of patents as a means to promote innovation (Thumm, 2004), this may intensify risks to scientific progress and innovation.

2006). Thus, the apparent success of the U.S. biotechnology sector may rest on an untenable long-term basis, an issue that has significance beyond the United States because the U.S. biotechnology innovation model is so widely emulated in other countries (Mowery & Sampat, 2005).

2.2.2 Efforts to Catch Up in Modern Biotechnology in Europe

In Europe, excitement similar to that in the United States about the creation of a new industry was quite lacking in the late 1970s and early 1980s (Bud, 1993). Instead, the first reactions in Europe to the 1970s scientific breakthroughs in genetic engineering and the concomitant developments in the United States were rather fearful. Reservations towards modern biotechnology, and especially the commercial exploitation of new genetic engineering techniques, were quite widespread as the potential risks and horrors were often considered to outweigh possible benefits (Bauer, Durant, & Gaskell, 1998; Bud, 1993; Torgersen et al., 2002).[15] Ethical debates were heated in many European countries as critics perceived in biotechnology "a technological and reductionist perception of life itself, one that seeks to instrumentalise life for the sake of profit" (Torgersen, Hampel et al. 2002: 16). Observable in debates and discussions in nearly all European countries was a tendency to engage a wider scope of issues than in the United States, rarely concerning just the technology but also involving broader societal discourses about ethics (Torgersen et al., 2002).

However, while public opinion was largely opposed to modern biotechnology, policymakers in many European countries were propelled to react to the changes taking place in the United States by fear of being left behind. The United Kingdom was the first European country to react fully to modern biotechnology. Germany had been proactive in fostering its biotechnology sector since the early 1970s, putting forth a *DECHEMA*[16] report in 1972 that outlined an ambitious program of state intervention to nurture its biotechnology sector. However, this report dealt mostly with the traditional approach to biotechnology, associating biotechnology with microbiology, chemistry, and biochemistry (Goujon, 2001). The United Kingdom, in contrast, did not take direct action with regard to biotechnology until 1979,

[15] Obviously, debates differed between countries, but differences within Europe were smaller than those between Europe and the United States (Bauer et al., 1998; Torgersen et al., 2002).

[16] *Die DECHEMA Gesellschaft für Chemische Technik und Biotechnologie e.V.* (Society for Chemical Engineering and Biotechnology).

with the consequence of this delay being that the British government was able to take into account the progress in genetic engineering techniques which deeply influenced the concept of biotechnology from the mid-1970s onwards (Goujon, 2001).

The 1970s had been a gloomy decade economically for the United Kingdom at least to the same extent as it had been for the United States. As in the United States, radically rising oil prices created massive inflation, and traditional manufacturing industries lost export markets to cheaper competition with nothing apparently filling their place, leading to fears of mass unemployment. Japan became an overwhelming challenge on the international economic stage. Government officials and civil servants were aware of the urgency with which new sources of work and industrial renewal needed to be sought. It seemed to many that the old industries should be replaced by new industries just as, half a century earlier, textiles and coal had been replaced by chemicals and electronics. Given the strong tradition of biology research in the United Kingdom, as well as sizeable government research institutes and large oil and chemical companies seeking diversification, biotechnology appeared to be a solution to many of the crushing worries at the time (Goujon, 2001). Where previously the nation had made and used machine tools, now the United Kingdom would make and use biological organisms. In this transformation, it was widely expected, science would have a huge role in driving biotechnology to be the new means to industrial and economic rebirth (Bud, 2010; Goujon, 2001).

Consequently, the Spinks Committee was formed in 1979 as a collaborative enterprise between the Advisory Council for Applied Research and Development, the Advisory Board for the Research Councils, and the Royal Society. This Committee was tasked with reviewing existing and prospective science and technology relevant to industrial opportunities in biotechnology (Bud, 2010). In the report it produced, the Spinks Committee came to a rather devastating conclusion concerning the state of biotechnology in the United Kingdom, claiming that the British structure of public and private support for R&D was not well suited to the development of a subject like biotechnology. This was, the Spinks Report posited, because strategic applied research was not well served by the research funding mechanisms in existence at the time, especially in an area such as biotechnology where there were neither university departments to promote it nor well-developed industries to provide market pull (Bud, 2010). Thus, the Spinks Committee Report posited, the United Kingdom needed a strong government-led strategy to foster its biotechnology industry. The key elements in this strategy would be

sufficient funds, strong engagement of the research councils through substantially increased support and coordination of activities in a Joint Committee for Biotechnology, coordination of government departments, and creation of an interdepartmental steering group (Gottweis, 1998). Overall, the Spinks Committee Report reflected a sense of crisis and urgency, depicting the need for a biotechnology strategy as crucial in the face of worldwide competition (Bud, 2010).

The sense of crisis and urgency reflected in the Spinks Report was intensified by the shock that same year, 1979, caused by the announcement that scientists in the United States had obtained two patents on the hybridoma technique developed by Milstein and Köhler in Cambridge in 1975 (De Chadarevian, 2011). Having been turned down by the university authorities in his attempt to patent the discovery, Milstein had freely distributed the myeloma cell line required for the production of monoclonal antibodies. Scientists at the Wistar Institute in Philadelphia had accepted cells from Millstein and their patenting of a technique for producing monoclonal antibodies against tumor antigens was considered by many to be an obvious extension of Köhler and Milstein's original invention, causing great controversy in the scientific community. However, in the United Kingdom, the shock caused by the patenting announcement went beyond the scientific community. The perceived failure of the responsible British authorities to file a patent on the technology grew into a scandal. It conjured up an old perception of the United Kingdom's inability to transform research advances into commercial products, as the missed opportunity to secure the rights to the commercialization of penicillin in the early 1940s was still very much a live issue (De Chadarevian, 2011).

As the United Kingdom entered the 1980s, there was thus a great sense of shock, crisis, and urgency to develop a modern biotechnology sector. Although the change in power following the 1979 elections meant a modification in the government strategy proposed in the Spinks Report, the new government quickly declared its belief that biotechnology would be of key importance in the world economy (Bud, 2010). The first major government statement on biotechnology after the change in power followed many of the key recommendations of the Spinks Report, although it indicated a change in strategy for pursuing the outlined goals into "relatively intensive" intervention. The strategy developed for biotechnology made the following central recommendations (Gottweis, 1998: 116):

- to strengthen the scientific base of biotechnology within the existing framework of funding, mainly by concentrating and shifting resources
- to coordinate the government's biotechnology-related activities between government departments, and between those departments, the research councils, the National Research Development Corporation, the National Economic Development Council, and the National Enterprise Board
- to coordinate and foster collaboration between universities, research councils, and industry
- to encourage the increase of private investment into the biotechnology industry
- to remove regulatory constraints inhibiting biotechnological development
- to foster international collaboration and competition

This targeted strategy focused on more efficient use of existing resources and facilities on national and international levels rather than on increasing government resources for biotechnology. However, this strategy required substantial intervention from the state and the cooperation of industry (Gottweis, 1998). Thus, although the Spinks Report recommendations for far-reaching collaboration between research councils, government, and industry were not fully implemented, even the limited implementation led to new models of science that would be significant in the emergence of a re-construction of science (Bud, 2010). Government policymakers worked with the Royal Society to help bind together the triple helix of industry, government, and science.

The establishment of a research-oriented biotechnology company was one of the recommendations of the Spinks Committee. This recommendation was followed with the formation in 1980 of the first British biotechnology firm, Celltech, as a private–public cooperation to exploit the advances made at the Laboratory of Molecular Biology at Cambridge, considered the United Kingdom's "national champion" in the emergence of molecular biology. Its Nobel Prize count was unparalleled. However, in commercial development it did not seem like a world leader in 1980, especially when examined against the backdrop of U.S. commercialization successes in biotechnology already emerging by 1980 (Bud, 2010). The Spinks Report had also called for

concerted efforts to improve commercialization of science across the board. This was a key inspiration for the Medical Research Council to rethink its policies regarding the commercial exploitation of its research. Consequently, beginning in the early 1980s, technology transfer became a key concern of the Medical Research Council, and various initiatives were put in place with the aim of redesigning lab–industry relations. The first private British biotechnology firm, Cambridge Antibody Technology, based on the new Laboratory of Molecular Biology technology of fully human monoclonals, was founded. Thus, a set of new policies regarding technology transfer, including a more generous reward system for researchers and Medical Research Council research units, was put in place to encourage and facilitate the commercialization of research findings (Bud, 2010).

These developments took place in a situation where discussion constantly alluded to an already existing, or at least threatening, U.S. superiority in high technology, a scenario perceived to undermine British industry and wealth (Bud, 2010). Moreover, it was around the early 1980s that the rhetoric of the high-technology race gained a new meaning, with three central metaphors increasingly used to construe the situation (Gottweis, 1998). One, Western Europe's viability was depicted as threatened. Two, a technology gap between Japan, the United States, and Western Europe was diagnosed. Three, Western Europe was seen to be in a technology race with its two main competitors, Japan and the United States. This political discourse was supported by interpretations of economists and innovation experts who expressed a consensus according to which Western Europe could only survive and thrive if it were to engage in the high-technology race and fight its technological and economic enemies of Japan and the United States. To do this, Western Europe would need to vigorously support and encourage its national industries and research systems to innovate, cooperate, and compete. Success on the technological front increasingly became represented as a strategy to keep Western Europe what it used to be and to save its identity. Science and technology had a strategic place in this project: the survival of Western Europe was thought to be secured only by facing up to the high-technology race. (Gottweis, 1998)

Moreover, in the early 1980s, only true optimists believed that the European semiconductor, telecommunications, computer, and consumer electronics industries could be effectively "saved." The competitive advantage of U.S. firms and, a bit later, of Japanese firms in semiconductors, computers, telecommunications, and consumer electronics increasingly raised the painful question of whether Western European industries were still viable in these

crucial technological sectors. In this context, attention turned increasingly to what was widely perceived to be the second important field for high-technology innovation after information technology: the new biotechnology (Gottweis, 1998). Moreover, this was a sector in which the United Kingdom could be considered a world leader in scientific terms. Thus, if the strength of the scientific base could be turned into commercialization successes to rival those already happening in the United States, this sector could revitalize the United Kingdom's industrial base and economy. It was against this backdrop that the United Kingdom started its efforts to catch up with the perceived lead of the United States in the modern biotechnology sector (Bud, 2010). Throughout the 1980s and early 1990s, the United Kingdom developed Europe's largest modern biotechnology sector, closely modeled on the strategies and institutional support structures that existed in the United States (Casper & Kettler, 2001), but boosted by the government in view of the perceived lag, especially in commercialization savvy.

In the early 1990s, in the aftermath of the economic recession, modern biotechnology truly emerged as a "key technology" of economic significance across Europe and themes of economic competitiveness became prominent in European policy discussions. Many of the earlier worries expressed in the United Kingdom about falling behind became prominent in European-level policy discussions, as it became increasingly acknowledged that the United States held the leadership in commercial exploitation of modern biotechnology (Senker, 1998). The U.S. modern biotechnology sector seemed to boast a larger number of dedicated biotechnology firms, more revenues, more employees, and more patents (Senker, 1998). The "Europe Paradox" of "being good in science, bad in commercialization" became a central theme in discussions, as it was noted that a large number of key basic science discoveries in modern biotechnology had been made in Europe but their commercial potential not optimally exploited (Cooke, 2000; European Commission, 2002; Reiss et al., 2003). As an influential European Commission Green Paper put it:

> Europe suffers from a paradox. Compared with the scientific performance of its principal competitors, that of the EU is excellent, but … its technological and commercial performance in high-technology sectors … has deteriorated. One of Europe's main weaknesses lies in its inferiority in terms of transforming the results of technological research and skills into innovations and competitive advantages. (European Commission, 1995)

Successful commercial exploitation of modern biotechnology seemed to be primarily a U.S. phenomenon while it appeared that "Europe (had) fallen behind the (United States) in the commercial exploitation in biotechnology" (Senker 1998: 6). There was much discussion about the reasons for the existence of a commercial performance gap between the U.S. and European modern biotechnology sectors. Especially worrisome appeared to be the lack of dedicated biotechnology firms in Europe as these were observed to be driving much of the innovation and growth in the U.S. modern biotechnology sector. A variety of factors were thought to explain the shortage of dedicated biotechnology firms in Europe, the primary ones being lack of venture capital, insufficient networking, lack of knowledge of the new technology and its commercial potential by existing firms, and negative attitudes of the European academic sector towards entrepreneurship and industry (Senker, 1998; Sharp & Senker, 1999). Many in the European biotechnology sector also considered themselves disadvantaged because of censorious public views of modern biotechnology (Rabino, 1994).

These concerns set the agenda for much of the policymaking in different European countries as well as on the European Union level. Public policy was often employed to make up for the private sector shortcomings in order to foster a prosperous modern biotechnology sector (Reiss et al., 2005). Efforts to stimulate or to create a modern biotechnology sector in various European countries appeared successful, as dedicated biotechnology firms began to appear in greater numbers in the 1990s. However, the European modern biotechnology sector has not caught up with the U.S. one in terms of commercial success. By 2011, the European biotechnology sector[17] generated about $19 billion in revenues, less than one-third of the revenues generated by the U.S. biotechnology sector, although the total number of companies (1,883 including both public and private companies) exceeded that of the U.S. biotechnology sector. Altogether, these companies employed fewer than 50,000 employees, less than one-half of those employed by the U.S. biotechnology sector. (Ernst & Young, 2012) Moreover, perhaps even more dishearteningly, only a few large companies in Europe drove most of the growth while the rest of the industry saw its already struggling performance worsen (Ernst & Young, 2012; Ward & Hodgson, 2006; Ward, Hodgson, & Binding, 2005). However, while such figures have led many to believe that the European modern biotechnology sector is a bitter disappointment, it is

[17] In the Ernst & Young report referenced here, the European biotechnology sector includes the biotechnology sectors of Belgium, Czech Republic, Denmark, Finland, France, Germany, Ireland, Israel, Italy, Netherlands, Norway, Poland, Sweden, Switzerland, and the United Kingdom (Ernst & Young, 2012).

important to keep in mind that differences in the definition of biotechnology and in institutional contexts make comparisons difficult. Some have proposed that assertions of the supremacy of the U.S. biotechnology sector may simply reflect early empirical evidence concentrated on the U.S. experience, resulting in other countries' biotechnology sectors being evaluated using a U.S. view of biotechnology, which may result in misleading conclusions (Laage-Hellman, McKelvey, & Rickne, 2004).

Moreover, efforts to make the European modern biotechnology sector more like that in the United Stated may fail to foster commercial success and might even hinder it in the longer term. For instance, it is questionable whether emulating the U.S. intellectual property regime is beneficial for the modern biotechnology sector. The approach to patenting has been more reserved in Europe than in the United States, especially until the 1990s (Bud, 1993). For instance, some important patents, such as the 1988 "oncomouse" patent granted to Harvard University researchers, were refused in Europe.[18] Generally, in European patent law, biotechnology has been considered a technology unlike any other, with life forms usually seen as too special to become the property of a single organization or individual (Bud, 1993; Westerlund, 2002). This has contrasted with the situation in the United States, where a regulatory approach based on evidence alone has been endorsed (Bauer et al., 1998; Torgersen et al., 2002). However, beginning in the 1990s, the state's role in Europe was re-envisioned as restricted to encouraging a setting congenial to economic competitiveness, with state promotion of societal goals other than economic ones when regulating biotechnology considered inappropriate (Torgersen et al., 2002). The greater focus on economic competitiveness was accompanied by a move to increase biotechnology patenting (Thumm, 2001) and university patenting (Macdonald, 2011), so that the European intellectual property regime has increasingly come to resemble that of the United States.

However, as discussion and evidence from the United States suggest, increased privatization of science through patenting may not be conducive to scientific progress, innovation, and small firm success in the longer term. Thus, while there are indications that European science may already be more privatized than often recognized (Verspagen, 2006), this might not be a beneficial development despite the conventional wisdom which holds that strong and broad patent rights are conducive to commercialization success and economic progress. This is especially so because evidence shows that large European firms have already begun using strategic patenting, which poses a

[18] Although this patent was later granted, this was a special exemption.

threat to small companies (Blind, Edler, Frietsch, & Schmoch, 2006). Thus, rather than considering a less aggressive intellectual regime in Europe a hindrance to commercial success, it is worthwhile to note its benefits. Indeed, examples from the United Kingdom point to the importance of public, open science for innovation. Cambridge University did not patent until 2006, believing in the free distribution of academic knowledge, yet Cambridge Science Park is the most successful one in the United Kingdom (Macdonald, 2011). Similarly, the successful fight to keep the scientific information in the Human Genome Project from being taken over into private ownership was waged in order to ensure continued scientific progress (Sulston & Ferry, 2002). Indeed, recent results from British universities challenge the view that patents are the most effective route for information dissemination in the economy (Andersen & Rossi, 2011). Therefore, strong declarations of Europe's failure, as well as attribution of this perceived failure to weaknesses in privatization and commercialization, may be misleading.[19] Instead, it is important to consider the European biotechnology sector and the national biotechnology sectors that comprise it in proper institutional context.

2.2.3 Building Modern Biotechnology in Finland

Modern biotechnology caught the interest of policymakers also in Finland in the 1980s. However, unlike in the United Kingdom, policymakers in Finland emphasized the strengthening of the science base rather than the commercialization of science. This built on developments in the 1970s, during which Finnish political decision makers had set up one of the largest state committees ever, the "Technology Committee," tasked with drafting a national view for the technological future of the country. The committee presented a long-term program to introduce new technology into the Finnish economy and to raise the nation's overall technological level through resource increases for R&D. As a result of the decisions made in the 1970s, the Finnish government accepted continuous increases in R&D financing as a high-priority political target throughout the late 1970s and the 1980s with three fields of technology singled out for extra attention: microelectronics, biotechnology, and material technologies (OECD, 2005a). To further these aims, *Tekes* (the National Technology Agency) was established in 1983 to govern and expand the

[19] Even the "Europe Paradox" of "being good in science, bad in commercialization" has become questioned more recently as data indicates that European weaknesses reside both in its system of scientific research (because of weak funding) and in a relatively weak industry (Dosi, Llerena, & Sylos Labini, 2006).

technology program mechanism originally launched by the Technology Committee.

Beginning in 1984, various public actors started funding research in modern biotechnology. The newly founded *Tekes* and *Sitra* (the Finnish National Fund for Research and Development) funded the first modern biotechnology programs that started in 1984 and 1985. These programs were carried out in the biotechnology laboratory of the Technical Research Centre of Finland (*VTT*), the Institute of Genetic Technology at the University of Helsinki, and the Department of Biochemistry at the University of Turku (Kääriäinen, 2000). In 1988, the Ministry of Education also stepped in and began funding research in modern biotechnology with special programs. The Ministry of Education had identified research in biotechnology and molecular technology as one of its primary foci for development activities. The target of its special funding programs in biotechnology was to raise both the quantity and quality of biotechnological research and research training to a level that would give Finland a place at the forefront of biotechnological development. Directly serving this purpose, the "Biocenter Program" was initiated, which involved the founding of biotechnology centers affiliated with the universities of Helsinki, Oulu, Kuopio, and Turku (Viljamaa et al., 2007). These four biotechnology centers were to be sanctuaries where excellent science could be done without the intervention of university politics. Most of the funding in the Ministry of Education's special biotechnology programs was directed to these research centers (Academy of Finland, 2002).

Public funding to the biotechnology sector, in the form of research and technology programs as well as of public venture capital, increased tremendously throughout the 1990s (Viljamaa et al., 2007). Adoption of new rhetoric emphasizing the emergence of a knowledge-based economy and highlighting the importance of knowledge and high technology as major factors of international competitiveness helped justify such investment (OECD, 2005a). The success of the information and communication technology industries in Finland in the 1990s provided additional impetus to efforts to develop a modern biotechnology sector in Finland. This success, led by Nokia Corporation, was seen as confirmation that the elaborate public innovation support system was the right recipe for improving Finland's economic competitiveness (Schienstock & Tulkki, 2001). At the same time, the phenomenal success of Nokia caused many to dream of a "BioNokia" that would emerge from the biotechnology sector, thus broadening the technological basis of the economy (Hermans & Kulvik, 2005). Therefore, heavy public funding to biotechnology continued as the government hoped to

establish a modern biotechnology sector with the help of appropriately robust advancement programs. The policy system increasingly introduced top-down approaches targeting modern biotechnology R&D (Lacasa, 2007). The science-led strategy-from-above was extended beyond providing funding for research to also providing increased public venture capital for the establishment of primarily university spin-off startups. As a result, several dedicated biotechnology firms were founded in the 1990s, to the effect that the overwhelming majority of dedicated biotechnology firms in Finland currently have a history dating back no longer than the 1990s. As a result, most of the dedicated biotechnology firms in Finland closely cooperate with universities and half of them are located in university biotechnology centers or similar science parks (Hermans & Kulvik, 2004; Hermans, Kulvik, & Tahvanainen, 2005). This has led to a clustering effect, not spontaneously but rather by government design. The largest biotechnology cluster is located in the Helsinki metropolitan area and the second largest in the Turku area. There are also biotechnology concentrations in Oulu, Kuopio, and Tampere, although these are much smaller than those in the Helsinki area and the Turku area (Hermans et al., 2005).

In short, the Finnish biotechnology sector has been initiated, funded, and designed largely by the government. This has been done with the expectation that the government provision and orchestration of resources and knowledge flows would create a new industrial pillar for the Finnish economy, made possible by public compensation for vital resources that may be missing in a small economy with limited private capital (Viljamaa et al., 2007). However, although the Finnish biotechnology sector ranks among the best in Europe (Senker, Reiss, Mangematin, & Enzing, 2007), its performance has disappointed the hopes of policymakers and the expectations of the wider public. A BioNokia remains the stuff of dreams and the commercial biotechnology sector continues to be largely dependent on public support as a large portion of dedicated biotechnology firms in Finland are loss-making operations (Hermans et al., 2005). According to most recent detailed statistics, nearly half of Finnish dedicated biotechnology firms operated at a loss as they struggled to develop commercial applications of their inventions that would cover their high R&D expenses (Hermans et al., 2005). Hence, although public policy may be seen to have succeeded in fostering the building of an excellent science base (Nesta, Patel, & Arundel, 2003; Reiss, Hinze, & Lacasa, 2004; Reiss et al., 2003) with good output levels in terms of patenting activities and new firm creation (Reiss et al., 2005; Senker et al., 2007), the end goal of building a new profit-generating economic sector remains elusive.

2.3 MAIN CHARACTERISTICS OF INNOVATION IN MODERN BIOTECHNOLOGY

Analyses of historical developments in the modern biotechnology sector, primarily in the first-mover countries of the United States and the United Kingdom, have provided much of the material for constructing models of innovation in the biotechnology sector. In Finland, these models have been used largely as templates according to which a modern biotechnology sector should be developed, with studies of the Finnish biotechnology sector mostly focusing on its shortcomings compared to this template. Therefore, the present review focuses on the main characteristics of the biotechnology innovation models developed based on experiences in the United States and in the United Kingdom. Although these historical experiences have differed, especially in the early years of modern biotechnology sector development, the industrial structures in the two countries showed signs of convergence already in the 1990s (Senker, 1996).

Therefore, it is possible to note certain main characteristics of innovation in modern commercial biotechnology. These are the collaborative nature of innovation, extensive reliance on information acquisition, and tendency towards local agglomeration. However, while certain main characteristics can be identified in the literature, it should be noted that most of the literature on biotechnology innovation has focused on the pharmaceuticals industry (Senker, van Zwanenberg, Caloghirou, Zambarloukos, Kolisis, Enzing, et al., 2001). Therefore, it is possible that the literature predominantly describes biotechnology innovation dynamics in the pharmaceuticals industry, neglecting biotechnology innovation dynamics in other industries. Yet, as noted previously, biotechnology is applicable across a wide range of industries and there is evidence that biotechnology innovation dynamics vary between industries (Senker, van Zwanenberg, Caloghirou, Zambarloukos, Kolisis, Enzing, et al., 2001). Hence, the identified main characteristics of innovation in modern biotechnology should be considered provisional, open to revision upon further research. Nevertheless, as this is the current state of research, it is sensible to use these identified main characteristics to provide guidance.

Therefore, this section presents the main characteristics of innovation in modern biotechnology identified in the literature. The main characteristics of innovation in modern biotechnology are discussed as they relate to a dedicated biotechnology firm. However, before delving into a discussion of these main characteristics of innovation, it is necessary to contextualize them

within larger discussions concerning models of innovation. This is necessary because the modeling of biotechnology innovation has been affected by, and has affected, wider literature on innovation. Currently, it is possible to identify six "generations" of innovation models, which are: (1) the black box model, (2) linear models, (3) interactive models, (4) system models, (5) evolutionary models, and (6) innovative *milieux* models (Marinova & Phillimore, 2003; Rothwell, 1992). These are briefly reviewed next.

The first-generation innovation model was the black box model, which arose mainly as an attempt to incorporate technological progress into the economic equation by Solow (1957). In analyzing U.S. total factor productivity during the period from 1909 to 1949, Solow found that there was a component of economic growth that changes in capital and labor could not explain. Solow concluded that this component of economic growth could be attributed to technological advances and that about 90% of *per capita* output could be attributed to technological change. Solow did not clarify the process by which technological advances drove economic growth, leaving this as a black box and thus giving rise to the so-called black box innovation model. The black box model states that the innovation process itself is not important and that the things that count are its inputs and outputs. For example, money invested in R&D (input into the black box) will generate new technological products (outputs), but economists do not need to analyze the actual mechanisms of transformation.

The desire to open up the black box gave rise to the second-generation models of innovation. In these models, innovation was viewed as a linear step-by-step process of activities that led to the adoption of technologies by markets. The linear model came in two varieties: the first linear description of innovation was the so-called technology-push model that was closely related to the science-push model (Godin, 2006). According to this view, discoveries in basic science eventually lead to technological developments, which result in a flow of new products and processes to the marketplace (Rothwell & Zegveld, 1985). The second linear description of innovation was similar to the first except for its positioning of market pull instead of technological newness as the driving force of innovation. Thus, the two varieties of linear models differ in their approach to the driving force of innovation, but they share the view of the innovation process as a linear step-by-step process.

The linear models were regarded as very simplified pictures of complex interactions between science, technology, and the market. Researchers thus sought to provide a more thorough description of the innovation process. This led to the breakdown of the sequential view of innovation and the construction

of third-generation innovation models, the interactive models of innovation. The interactive models of innovation discarded the view of the innovation process as a linear process of separate stages. In its place, these models depicted the innovation process as a complex net of intraorganizational communication paths linking together various in-house functions (Rothwell & Zegveld, 1985). The main power of these models may be considered to lie in their explanations of the variety of interactions necessary for innovation.

While the interactive models of innovation focused on intraorganizational interactions, researchers such as Dodgson (1991b) and Marceau (1994), emphasized that the complexity of innovation requires interactions not only among a wide spectrum of agents within the firm but also with agents outside the firm. Writers, such as Sako (1992), described this phenomenon as the existence of dynamic innovation networks. Researchers consequently developed so-called system models to portray interorganizational interactions in the innovation process, giving rise to the fourth generation of innovation models. The system models argue that firms do not have to have large resources to develop innovation in-house as they can benefit from establishing relationships with a network of other firms and organizations.

Evolutionary models of innovation, which make up the fifth generation of innovation models, were largely in accordance with the system models, but placed more emphasis on the role of governments to shape the environment for innovation processes (Marinova & Phillimore, 2003). Evolutionary models argue that evolutionary processes embedded in socio-economic contexts largely determine innovation outcomes. Therefore, the evolutionary processes of interaction and collaboration that lead to innovation need to be understood in order for governments to create conditions conducive to innovation by shaping relationships, encouraging learning, and balancing competition with cooperation. The emphasis on government action in the evolutionary models makes it possible to argue that these models may be viewed as mainly producing policy recommendations, while the system models of innovation focus on firm-level processes.

Innovative *milieux* models of innovation are the sixth generation of innovation models. These models have much in common with systems models as both sets of models emphasize interaction and collaboration across organizational boundaries. However, innovative *milieux* models place great importance on geographical co-location for interaction and collaboration leading to innovation (Camagni, 1991; Camagni & Capello, 2000; Feldman, 1994; Keeble, 2000). Geographically bound innovative *milieux* are argued to

be characterized by dense networks, ease of communication, and high levels of trust, which are posited to foster innovation. Innovation *milieux* are also called "innovation clusters" (Porter, 1990).[20] According to the OECD (1999), the concept of a cluster is closely linked to firm collaboration and networking but goes beyond that as it captures all forms of knowledge sharing and exchange within a specific locality.

These six generations of innovation models may be viewed as different ways of looking at the complex processes of innovation rather as competing and mutually exclusive theories. Especially the latest three models—system models, evolutionary models, and innovative *milieux* models—may be seen as highly complementary as they all emphasize that evolving interorganizational interactions are essential for innovation. These three latest generations of innovation models are also the ones that have the most resonance with innovation dynamics in the modern biotechnology sector, especially in their emphasis on the importance of interaction and collaboration across organizational boundaries for innovation.

2.3.1 Interorganizational Collaboration

Innovation in the modern biotechnology sector has been characterized as highly collaborative, taking place in networks of formal and informal collaboration among various actors in the public and private spheres (Dodgson, 1993). Therefore, it is possible to describe innovation in modern biotechnology in line with the system models of innovation, emphasizing that the complexity of innovation requires interactions not only among a wide spectrum of agents within the firm, but also interactions and cooperation among agents in what may be called dynamic, industrial, strategic, or innovation networks (Dodgson, 1991a).[21] More specifically, innovation in modern biotechnology has been characterized as depending upon the

[20] Other closely related concepts are "the learning region" (Florida, 1995) and "collective learning" (Keeble, 2000).

[21] Innovation in modern biotechnology may also be understood through evolutionary models of innovation which, as noted before, may be considered complementary to system models of innovation. However, it can be argued that the evolutionary models of innovation direct attention largely toward understanding the evolutionary processes of interaction and collaboration in order for governments to create conditions conducive to innovation. This emphasis can thus be posited to lead to viewing innovation largely on the level of national innovation systems, an approach that has been widely employed in studies of modern biotechnology. However, in this study focus is on innovation from a dedicated biotechnology firm's point of view, where national innovation systems form a context of action rather than being the object of action.

contributions and interactions of three types of agents: universities, small research-intensive dedicated biotechnology firms, and large established corporations (Arora & Gambardella, 1990). These three sets of actors are said to be endowed with complementary assets to generate, develop, and commercialize modern biotechnology innovation (Arora & Gambardella, 1990; Dodgson, 1993), so that successful innovation in modern biotechnology requires the combination of these complementary assets (Dodgson, 1991a, 1991b).

Universities are considered central actors in modern biotechnology innovation because the modern biotechnology sector is characterized as science-based (Bogliacino & Panta, 2010; Pavitt, 1984), meaning that inventions are built up over long periods of time in the realm of publicly funded basic science (McMillan, Narin, & Deeds, 2000; Zucker, Darby, & Brewer, 1998). Hence, inventions in modern biotechnology emerge from universities rather than from the R&D departments of large companies (Kenney, 1998). Therefore, to gain access to the newest inventions in modern biotechnology, industry actors must collaborate with universities (Dodgson, 1991a; Rothwell & Dodgson, 1991). This collaboration can, and does, take various forms. Forms of collaboration have been noted to include, but not be limited to, licensing of university inventions by firms, university contract research and consulting, movement of university professors to take jobs in industry and/or to sit on industrial scientific advisory committees, and informal collaborations through social networks (Kenney, 1986; Liebeskind, Oliver, Zucker, & Brewer, 1996; Senker, 1996). The benefits of university-industry collaboration to firms have been posited to include, but not be limited to, access by firms to new inventions (McMillan et al., 2000), lowering of firms' R&D costs (George, Zahra, & Wood, 2002), and signaling value for firms of being associated with elite science in recognized hotspots of innovation (Lawton Smith & Bagchi-Sen, 2006).

However, to create innovation from invention, scientific knowledge and inventions need to be commercialized (Coriat, Orsland, & Weinstein, 2003). Small research-intensive firms or dedicated biotechnology firms have been found to play a central role in the commercialization of science in modern biotechnology. Typically, dedicated biotechnology firms are closely attached to universities, which is posited to furnish them with a comparative advantage in R&D transfer from universities vis-à-vis larger firms (Dodgson, 1993). This comparative advantage has been concluded to result from the greater ease of dedicated biotechnology firms to recruit the best scientists because of their closeness to universities, as well as their greater emphasis on

research, both things that larger companies have found difficult to accomplish (Kenney, 1998). Dedicated biotechnology firms are also said to enjoy a number of behavioral advantages over their larger counterparts in innovation, including rapid responses to external threats and opportunities, efficient internal communications, and interactive management styles (Rothwell & Dodgson, 1991). Large firms, on the other hand, have not been able to internalize the knowledge necessary to dispense with either university research or dedicated biotechnology firms (Kenney, 1998). Therefore, larger firms have found it necessary and advantageous to collaborate with dedicated biotechnology firms. As a result, dedicated biotechnology firms have continued to proliferate in the modern biotechnology sector even after large corporations moved into the field, rather than the sector becoming consolidated into a few large firms as it has matured (Kenney, 1998).

There are two explanations as to why dedicated biotechnology firms have remained so buoyant. One is that the science base underpinning biotechnology continues to move fast and dedicated biotechnology firms, with their privileged links with the science base, continue to perform a vital intermediary function of technology transfer between academia and industry. The other explanation is that dedicated biotechnology firms typify a new type of networked organization, already familiar in information technology, but now emerging in the chemical and pharmaceutical industries. Its advocates argue that the small firm retains a flexibility and innovativeness which larger firms find difficult to emulate, so that while the large conglomerate chemical/pharmaceutical firm certainly retains some advantages, the increasing number of linkages between large firms and dedicated biotechnology firms suggests that relationships may be changing (Sharp, 1996). However, it is also worth noting that in the British experience, fragmentation of the industry structure has been consciously maintained, with dedicated biotechnology firms being kept from being acquired by larger companies so that the modern biotechnology sector would not become consolidated in the same manner as the semiconductor industry, perceived to have led to its stagnation (Oakey, Faulkner, Cooper, & Walsh, 1990).

However, despite their comparative advantage, small dedicated biotechnology firms have also been noted to suffer from a number of mainly material disadvantages, such as inability to spread risk over a portfolio of new products, problems in funding longer-term R&D, and difficulties in establishing an appropriate network of contacts with external sources of scientific and technological expertise and advice (Rothwell & Dodgson, 1991). Particularly debilitating is believed to be the common lack on the part of

dedicated biotechnology firms of "complementary assets" such as competitive manufacturing, marketing and distribution networks, and ability to deal with regulatory procedures necessary in bringing new products to market. These complementary assets are all necessary for firms to attain full returns from innovation. Therefore, the lack of these complementary assets has led to dedicated biotechnology firms often finding it necessary and advantageous collaborate with larger firms. Hence, the distinctive advantages on the part of dedicated biotechnology firms (superior ability to internalize the latest scientific knowledge) and on the part of large firms (possession of complementary assets) have provided the basis for collaborations. Innovative startups have been able to overcome resource restrictions through collaboration with larger firms, so that collaborative linkages are an important means of improving innovation potential. The dominant trend has been for dedicated biotechnology firms to conclude cooperative agreements with large firms that have the skills and resources to take innovations developed in dedicated biotechnology firms to market (Kenney, 1998).

There are also key intermediaries that help facilitate interactions between the three main sets of actors in modern biotechnology innovation. Particularly noteworthy are venture capitalists, which have been instrumental in helping to found and develop dedicated biotechnology firms in the United States. Indeed, Genentech had its start as a collaboration between a university professor and a venture capitalist (Hughes, 2011; Powell, 1999). Venture capitalists play a crucial role in the U.S. modern biotechnology sector as they invest in new, untested technology, something that large corporations and banks are reluctant to do because of the high risk. Moreover, venture capitalists take an active role in accelerating dedicated biotechnology firm growth, as their objective is to increase the value of the fledgling company rapidly. Venture capitalists help dedicated biotechnology firms secure professional legal and accounting assistance, hire key executives, contact potential business partners, and find the right underwriters for a public offering. In short, venture capitalists provide both the capital and the contacts necessary for a firm to become self-sufficient (Kenney, 1998). The actions carried out by venture capitalists have been argued to be vital in the successful development of dedicated biotechnology firms in the United States, and the shortage of venture capitalists in Europe compared to the United States has been found to be a key hindering factor in the development of the European modern biotechnology sector (Ward & Hodgson, 2006; Ward et al., 2005).[22]

[22] The shortage of venture capitalists in Europe compared to the United States is typically attributed to the fact that venture capitalists are a historically unique U.S.

As a result, the functions fulfilled by venture capitalists in biotechnology innovation often need to be filled by other means in biotechnology sectors outside of the United States. In Finland, public organizations have tried to make up for the shortage of private venture capital by supplying public R&D subsidies, public venture capital, and publicly funded aid for networking.[23]

2.3.2 Information Acquisition[24]

Although interorganizational collaboration in modern biotechnology has been found to result from complementary resource allocations, critically including material resources such as manufacturing and distribution networks, analyses of collaboration have led researchers to posit that the most crucial resource being shared in these collaborations is knowledge (Powell, 1996). Running through the literature on collaboration is the argument that collaboration enhances organizational learning (Dodgson, 1993; Powell, 1996). This is argued to be the case because the knowledge base of the modern biotechnology sector is complex and expanding with sources of expertise widely dispersed, which results in the locus of innovation being located in networks of learning rather than in individual firms (Powell, Koput, & Smith-Doerr, 1996). Thus, the large-scale reliance on interorganizational collaborations in the biotechnology sector is posited to reflect a fundamental and pervasive concern with access to knowledge (Powell, 1998; Powell et al., 1996). In other words, knowledge is argued to be the "lifeblood" flowing through the channels and conduits of collaborative networking for innovation in biotechnology (Owen-Smith & Powell, 2004). These arguments are given further weight by the frequently made acknowledgement that biotechnology is a knowledge-driven sector, consisting of "knowledge working on knowledge" to create value (Cooke, 2002a).

Hence, as knowledge is seen as the most crucial resource in modern biotechnology innovation and the knowledge base is noted to be highly distributed, much of the vitally needed knowledge on the part of a dedicated biotechnology firm necessarily lies beyond its organizational boundaries. This

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phenomenon, coming into being in the post-World War II United States with the lead of American Research and Development Corporation whose aim was to supply risk capital to new companies based on scientific research (Kenney, 1998; Senker, 1996).

[23] Primarily through *Tekes*, *Sitra*, and *Finpro* (The National Trade, Internationalization and Investment Development Organization), respectively.

[24] The term "knowledge" is used here in accordance with the terminology used in the literature reviewed but it is worth noting that it is typically not distinguished from information in this literature.

makes it inevitable that information acquisition plays a significant part in modern biotechnology innovation. This is in line with system models of innovation which argue that firms do not have to have large resources to develop innovation in-house as they can benefit from establishing relationships with a network of other firms and organizations (Dodgson, 1991b).

Considering information acquisition from the perspective of a dedicated biotechnology firm, access to knowledge produced by universities is critical for innovation. However, the scientific knowledge produced in universities and research institutes requires multiple additional information inputs in order to be turned into technologically and commercially feasible innovation. The importance of this must be emphasized, as it is precisely the problems in translating scientific knowledge into technologically and commercially feasible innovation that have been posited to lie at the core of the "Europe Paradox." Thus, scientific knowledge inputs are only one part of the multiple knowledge resources needed to produce modern biotechnology innovation (Laage-Hellman et al., 2004). Complementary information concerning product formulation, production, protection of intellectual property, and marketing is essential (Walsh, Niosi, & Mustar, 1995). Therefore, as access to multiple information sources is crucial for turning invention into technologically and commercially feasible innovation, a dedicated biotechnology firm needs extremely good capabilities to identify, access, analyze, utilize, and combine information from a multiplicity of different sources. Although this phenomenon is by no means exclusive to the modern biotechnology sector—indeed, it is argued that to widen the range of recombination opportunities for innovation, all firms should seek to combine internal competences with information from external sources (Galunic & Rodan, 1998; Hargadon, 2003; Rodan & Galunic, 2004)—this phenomenon may be considered to be particularly pronounced in biotechnology innovation.

Moreover, the knowledge necessary for innovation in modern biotechnology has considerable tacit components. Indeed, it can be claimed that all of this needed knowledge, including scientific knowledge, is partially tacit (Senker, 1995).[25] Thus, as Senker argues, although firms build up their own practical experience in-house by undertaking research and development and by interacting with production, they may acquire knowledge also from external sources, with all of this knowledge having tacit components (Senker, 1995). Such partially tacit knowledge, it is argued, can be acquired only by

[25] This is in line with Polanyi's original argument about tacit knowledge (Polanyi, [1966] 1983; Tsoukas, [2003] 2005).

personal experience or through personal interaction with experts. Furthermore, this applies also to scientific and technological knowledge, where personal interaction with the sources of new scientific or technological knowledge has been found to be compulsory in order to capture fully the tacit dimension (Senker, 1993, 1995). This is especially true in new areas of research such as modern biotechnology. Considering this argument in the context of modern biotechnology innovation, it can be concluded that a dedicated biotechnology firm must be able to acquire knowledge with tacit components from multiple external sources. This is because if, as posited in studies of innovation in modern biotechnology, a dedicated biotechnology firm is reliant on external knowledge for innovation and all of this external knowledge has tacit components, then the inevitable conclusion is that a dedicated biotechnology firm is reliant on external knowledge with tacit components for innovation. Furthermore, the acquisition of knowledge in full—that is, comprising both codified and tacit dimensions—can be assumed to require personal interaction with the sources of knowledge, which in turn requires personal contacts and social networks (Senker, 1993).

2.3.3 Local Agglomeration and International Information[26] Acquisition

The argument that innovation in modern biotechnology relies heavily on external knowledge that always has tacit components, which can be captured only in personal interaction, is in line with the common assertion that modern biotechnology innovation evinces strong tendencies towards local agglomeration into clusters. Material aspects are important in explaining this agglomeration, as they are in explaining interfirm collaboration. Therefore, researchers such as Prevezer (1996, 2001) and Audretsch et al. (Audretsch, 2001; Audretsch & Stephan, 1996) have posited that modern biotechnology innovation and subsequent business activity first arose in those regions of the United States—the San Francisco Bay Area and Boston—that provided the right combination of resources: scientific excellence, capital, and complementary business assets. Additional biotechnology clusters have arisen since in other regions of the United States and in other countries (although often in a manner that has been more induced by state policies than

[26] The terms "information" and "knowledge" are used here in accordance with the terminology used in the literature reviewed, but it is worth noting that the two concepts are typically not distinguished, at least not consistently, in this literature.

spontaneous), arguably most successfully in areas with complementary resources and reinforcing sets of factors (Chiaroni & Chiesa, 2005, 2006).[27]

However, researchers have pointed to social networks, and the access to tacit knowledge that they provide, as being a significant reason for local agglomeration tendencies in modern biotechnology (Owen-Smith & Powell, 2004; Powell, Koput, Bowie, & Smith-Doerr, 2002; Powell, White, Koput, & Owen-Smith, 2005). Thus, notwithstanding the acknowledgement of the role of complementary resources in cluster formation, a core argument is that local agglomeration reflects the geography of information flows. Several researchers argue that modern biotechnology innovation is strongly localized, emerging in clusters of co-located actors who are able to access effectively each other's knowledge because of their physical proximity (Audretsch & Feldman, 1996; Cooke, 2002a). Such co-location in clusters is argued to be especially important for innovation in a sector such as modern biotechnology, which relies on new scientific knowledge and is thus heavily dependent on tacit knowledge communication (Audretsch & Feldman, 1996). Empirical studies, such as those by Zucker et al. (Zucker, Darby, & Armstrong, 1998, 2002; Zucker, Darby, & Brewer, 1998), support this view as they have found that where and when star scientists in biotechnology actively produced publications was a key predictor of where and when commercial firms first began to use biotechnology. Moreover, studies by Zucker et al. and others (Liebeskind et al., 1996) posit that the existence of personal, often informal, ties between individuals is crucial for successful formal interaction between organizations.

Powell et al. take this argument further, claiming that clusters of collaboration are embedded in an ecology rich in informal social networks, out of which formal corporate ties grow (Owen-Smith & Powell, 2004; Powell, Koput, Smith-Doerr, & Owen-Smith, 1999). As Powell et al. put it: "social and intellectual ties, forged as early as graduate school days, link scientists across firms and universities, facilitating collaboration" (Powell et al., 1999: 156). Moreover, it is posited that these ties are local because of the importance of tacit knowledge and the face-to-face contacts that its sharing necessitates (Owen-Smith & Powell, 2004; Powell et al., 2002; Powell et al., 1999). These informal and formal ties thus act as channels and conduits for knowledge,

[27] Beyond analyses of the early growth of the biotechnology sector in the United States that show a relatively spontaneous cluster emergence in the San Francisco Bay Area and Boston, several clusters to be found internationally have been built largely through government policies. As the focus in this study is on firm-level innovation and not on government policy, most of the literature on biotechnology clusters thus falls outside the scope of this study.

facilitating access to the multiple external knowledge sources that are crucial to an innovating firm in the biotechnology sector.

However, studies of biotechnology firms' networking in European countries have produced diverging results, as local knowledge networks have been found to be eclipsed in importance by national and international knowledge ties. In the United Kingdom, it has been found that there is a clear tendency for interfirm and university–firm collaborations to be more intensive with distant partners—national and international—than with local actors (Hendry & Brown, 2006). In France, researchers have found that while biotechnology firms rely on local infrastructures in their early stages, their networks become international as they mature (Lemarie, Mangematin, & Torre, 2001). Studies in Sweden, whose economy is most like that of Finland, have found that global knowledge collaboration is indispensable for dedicated biotechnology firms. It is concluded that the convenience of local collaboration cannot replace the extreme requirement for specialized knowledge, which forces Swedish biotechnology firms to seek collaborators in the global arena, despite the impediments they face in these situations (McKelvey, Alm, & Riccaboni, 2003; Moodysson & Jonsson, 2007). No specific studies of the geography of knowledge networking by biotechnology firms have been done in Finland, but Luukkonen (2005) alludes to the possibility that the majority of Finnish biotechnology firms' partners are located abroad because of the small size of the Finnish economy. Therefore, it can be assumed that for a dedicated biotechnology firm from Finland, much of the needed knowledge necessarily lies beyond national boundaries due to the small size of the home country. Therefore, it is important to look at international information acquisition.

2.4 PERSPECTIVES ON INFORMATION[28] ACQUISITION IN INTERNATIONAL BUSINESS

In international information acquisition, particularly meaningful is that it takes place across national borders. There are strong indications that many firm-related processes meet with additional challenges when they take place internationally: these have to do with differences in language, culture, institutional contexts, and "outsidership" of a firm in foreign countries. Therefore, a field of literature that seems promising as a source of insights for

[28] The terms "information" and "knowledge" are used here in accordance with the terminology used in the literature reviewed, but it is worth noting that the two concepts are typically not distinguished, at least not consistently, in this literature.

international information acquisition is international business studies as this literature explicitly deals with issues that arise when firms cross national borders in conducting their activities.[29]

Defining international business studies literature is challenging, as its boundaries are fuzzy and porous. As Caves (2003: 1) put it: "international business designates not a class of decisions but a group of firms that face decision-making problems beyond those that confront single-nation businesses or encounter the same problems transformed by their international context." Therefore, international business studies literature is defined for the purposes of this dissertation as the field of study that revolves around the issues that arise when business activities are conducted internationally. This definition is in line with that put forward by the *Journal of International Business Studies*, which many researchers (DuBois & Reeb, 2000) consider to be the main publication in the field of international business. Nonetheless, due to the porous boundaries of the field, literature pertaining to international business activities is published in a wide variety of journals. The literature reviewed in this section is chosen according to its relevance to the phenomenon studied, that of (external) information acquisition for innovation in a small, internationally operating company in the biotechnology sector originating from a small, developed economy.

International business studies literature lacks a shared set of underlying theoretical assumptions or a shared interpretive framework (Cantwell & Brannen, 2011). Accordingly, it is possible to identify four different perspectives in international business literature regarding information acquisition that are based on quite distinct theoretical foundations. These perspectives provide diverging approaches to viewing information acquisition in international business, particularly with regard to what are considered the greatest obstacles and their possible solutions. These four perspectives are reviewed next, primarily in the chronological order in which they have arisen in international business studies literature. Although they all draw on other literature, sometimes merging with larger paradigms in economics, organization science, and sociology, the discussion in the case of each perspective is limited to its development and uses within international

[29] Literature addressing international activities by smaller firms is of relatively recent vintage in international business studies and is typically labelled "international entrepreneurship research," considered to have emerged mostly in the 1990s (Jones et al., 2011). However, this stream of literature has yet to develop a proprietary theoretical framework concerning international information acquisition and instead primarily draws on international business literature theory (Fletcher & Harris, 2012). Hence, it can be included as part of international business studies literature for the purposes of this dissertation.

business studies literature. The terms “information” and “knowledge” are used here in accordance with the terminology used in the literature reviewed.

2.4.1 Information Transactions

The first perspective to examining information acquisition that may be identified in international business studies arose in the 1970s based on the discipline of economics. This perspective utilizes transaction cost theory and focuses on problems of information transactions. Although the terms “know-how” and “knowledge” are used synonymously with the term “information” in this approach, the latter term is used here to characterize this perspective because it draws so strongly on Arrowian information economics.

To understand this line of theorizing, it is important to recap briefly the earliest developments in international business literature on which this work built. International business theories may be seen as having first arisen to explain a key question considered problematic in neo-classical trade theory, namely, why foreign direct investment (FDI)[30] exists (Dunning, 2003; Hymer, 1960). In neoclassical trade theory, factors of production are assumed to be fixed in specific locations while goods can move freely around the world. Consequently, in perfect markets, firms would produce locally and trade their goods. This is because local firms, assumed to have superior information about the local market, would have a comparative advantage in their home market vis-à-vis foreign firms. Hence, a “local production- international trade” scheme would maximize each firm's comparative advantage. Therefore, in perfect markets, it would make no sense for a firm to undertake foreign direct investment because it would be always out-competed by local firms because of its “information handicap” (Dimand, 2004; Hymer, 1960). However, in the real world, foreign direct investment did exist. The earliest international business theories—typically considered to have started with Hymer’s (1960) dissertation that called attention to this paradox between theory and practice (Dunning, 2003)—were geared toward explaining this apparent paradox. Internationally operating firms, it was concluded, must possess some advantage over local firms that enabled them to overcome their information handicap (Hymer, 1960; Kindleberger, 1969; Knickerbocker, 1973; Vernon & Wells, 1966).

[30] Defined as having controlling majority ownership of 51% or more in a business operation abroad (Hymer, 1960).

Transaction cost theory posits that the advantage which makes foreign direct investment sensible derives from the ability of internationally operating firm to bypass "natural" imperfections of international markets (Buckley & Casson, 1976; Hennart, 1977, 1982).[31] This theorizing starts from the premise that there are two ways to organize interdependencies between individuals: the market, which utilizes the price mechanism, and the firm, which utilizes the hierarchy mechanism. In perfect markets, the price mechanism is the most efficient organizational method. Consequently, in perfect markets, international trade, which relies on the price mechanism, would be the optimal solution. However, it is argued that there are "natural" imperfections in markets, principally bounded rationality and opportunism, which make markets less than perfectly efficient. The existence of market imperfections causes the hierarchy mechanism of the firm to be the more efficient manner of organizing. Therefore, when market imperfections exist in international markets, foreign direct investment that gives rise to the multinational corporation, is the more efficient organizational method.

Although several types of transactions may be more efficiently organized using the hierarchy mechanism of the firm rather than the price mechanism of the market, transactions involving information present a particularly salient case. Indeed, most applications of transaction cost theory to multinational corporations have focused on the organization of international interdependencies involving information, arguing that the multinational corporation arises when internalizing markets for information is the most efficiency way of organizing (Buckley & Casson, 1976; Hennart, 1977, 1982, 2003).[32] Information transactions are argued to be special, because information as an economic good has many characteristics that differentiate it from other economic goods. In transaction cost theorizies in international business, two particularly prominent characteristics of information are highlighted as reasons to internalize information transactions within the firm:

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[31] According to Hennart (2003), transaction cost theories in international business literature were developed independently of transaction cost theories in economics by Williamson (1985). Consequently, it is transaction cost theories as developed in international business literature that are focused upon here.

[32] The term "information" is used here to characterize this approach to information acquisition, as the arguments in this stream of international business theorizing relating to information largely draw on Arrowian information economics (Arrow, 1962, 1984, 1999). Hence, although terms such as "know-how" and "knowledge" are used in transaction-cost based international business theorizing, they are typically used (quite) synonymously with the term "information" as treated in information economics. Consequently, the discussion here will, in line with the information economics basis of this argument in international business studies, use the term "information" throughout for clarity and consistency.

these are information asymmetry and the public good characteristics of information.

Hennart (1977, 1982, 2003) focused in his work particularly on information asymmetry—an idea developed principally by Arrow (1962, 2001)—as the rationale for internalizing information transactions in international markets and thus forming a multinational corporation. Information asymmetry arises because one party cannot obtain freely (or at all) the information available to another (Arrow, 1996). Hence, the buying and selling of information is not the same as the buying and selling of most other goods, because there are greater opportunities for cheating in information transactions. This is because the value of information being sold is hard (if not impossible) for the buyer to gauge. This could be achieved only if the seller allowed the buyer to inspect fully the information being sold, but doing so would lead to a situation where the seller would no longer have anything worth selling. In other words, it is difficult (if not impossible) for the seller to simultaneously advertise and protect the information being sold, while it is difficult (if not impossible) for the buyer to gauge its value.

Hence, the price mechanism often does not work well when the good being transacted is information because there are so many possibilities for the agents to cheat. This means that it can be more efficient to internalize information transactions by subjecting them to the hierarchy mechanism of the firm. When the agents transacting information are located in different countries, it is efficient to internalize the transactions within a multinational corporation. This explains the existence of a multinational corporation even in the face of the information handicap. As Hennart put it:

> Know-how developed in one country is often potentially useful in others and can be transferred at low marginal cost. Markets for know-how suffer, however, from the fundamental problem of information asymmetry. For markets to function well, buyers and sellers must have perfect knowledge of what is being sold. As Arrow first argued, the buyer of know-how does not generally know its exact characteristics, and the seller cannot provide the buyer with that information, since by doing this he would be transferring his know-how to the buyer free of charge. ... Transfer within a firm can then be more efficient, because both the sender and the receiver of the know-how are now rewarded for effective transfer, and not for cheating each other as in a market setting. Buyers and sellers of knowledge will therefore form an MNE (multinational enterprise) and put their behavior under the

> control of a central party charged with maximizing their joint income. (Hennart 2003: 137)

Buckley and Casson (1976), while making the same general argument of benefits of internalizing information transactions, emphasize a different aspect of information as an economic good that causes it to differ from most other economic goods: the public good character of knowledge. A public good is defined as having two distinct characteristics: non-excludability and non-rivalry. Non-excludability means that an individual cannot be prevented from consuming the good, while non-rivalry means that several individuals can consume the same good without diminishing its value. These characteristics lead, in Buckley and Casson's theory, to information having the critical properties of being easily transferred and hard to protect. Hence, there might be free riders who utilize the information without paying for it. This is clearly not in the interests of the economic agent who owns the information, as it can lead to depreciation of the value of the information for that specific agent in a competitive situation. As a result, Buckley and Casson argue, it is advantageous to internalize information transactions, as this makes it possible for the multinational corporation to exploit the information in all of its locations while simultaneously protecting it from competing economic agents. As Buckley and Casson put this:

> There is a special reason for believing that internalization of the knowledge market will generate a high degree of multinationality among firms. Because knowledge is a public good which is easily transmitted across national boundaries, its exploitation is logically an international operation. (Buckley & Casson, 1976: 45)

This section has focused on the two arguably most prominent sources of transaction cost theorizing in international business literature, as they cover the gist of the argument in this perspective. To summarize, it is posited in this perspective that information transactions in markets can be inefficient because of possibilities to cheat and free ride that arise from information asymmetry and the public good characteristics of information. These problems, it is argued, can be alleviated by internalizing information transactions within multinational corporations. Hence, multinational corporations come into being when they are efficient vehicles for organizing information transactions. This efficiency arises from their possibilities to correct for, or overcome, "natural" market imperfections that are particularly salient in the case of

information as an economic good (Dunning & Rugman, 1985). Hence, by internalizing information transactions, multinational corporations can alleviate problems of opportunism, cheating, and free riding that are said to be prominent in information transactions. In sum, "an MNE (multinational enterprise) will expand abroad (will organize interdependencies through hierarchy, i.e. through employment contracts) when it can organize interdependencies between agents located in different countries more efficiently than markets" (Hennart 2003: 136).

This approach to viewing information acquisition as information transactions that are particularly problematic to organize in markets leads to a view that emphasizes the benefits of internalizing information transactions. This leaves open the question of how small firms in international business, which have internalized only a small portion of their information transactions (by definition), are able to acquire information in international markets. More specifically, how are they able to compete with large multinational companies as they are forced to rely on the market for information transactions while the large multinationals enjoy the benefits of internalized information transactions? One answer could be that these small firms operate in markets that approximate perfect markets and therefore do not suffer from market imperfections. Yet, as the markets in which small firms operate are often the same as those in which large multinational corporations compete, this conclusion would not seem likely. Indeed, this perspective would imply that information acquisition in international markets is performed best by internalizing information transactions, leaving smaller firms at a disadvantage.

However, a more recent development can shed light on how small firms may be able to compete in international markets even if unable to internalize most information transactions. This is the so-called network view, where it is posited that there is a third organizing method in addition to markets and hierarchies, that of networks. Focusing on the network view as developed primarily on the basis of transaction cost theories, Casson (2000) and Buckley et al. (Buckley & Hashai, 2004) posit that information transactions within networks may be defined as an additional type of information transaction that lies between "internal" and "external" information transactions. Information transactions within networks are characterized as "external" information transactions in that they do not take place within the firm but have the quality of intrafirm information transactions. These kinds of information transactions, in this view, can therefore correct for market imperfections in the same way that internalized

information transaction do, even though they take place across firm boundaries.

This perspective to information acquisition in international business implies that a small firm should develop network relationships in which it could conduct information transactions in an internalized manner. In this way, small internationally operating firms could acquire information without being disadvantaged by market imperfections for information transactions, finding a way to compete with larger multinational companies. However, the literature does not go into much detail concerning how such network relationships could be formed or maintained beyond mentioning the importance of shared codes and trust.

2.4.2 Experiential and Network Learning

The second perspective to examining information acquisition that may be identified in international business studies focuses on explaining firm international growth and internationalization. The core of this perspective is the so-called Uppsala Model, first presented in 1977 (Johanson & Vahlne, 1977), relaunched in 1990 (Johanson & Vahlne, 1990), and revised in 2009 (Johanson & Vahlne, 2009). The crux of the Uppsala Model's approach to information acquisition is the emphasis on experiential learning—a notion adopted from Penrose ([1959] 1995)—which is hampered by "psychic distance" and "outsidership" in foreign countries.[33] Thus, this model explains firm international growth as centrally revolving around knowledge acquisition. As Johanson and Vahlne put it:

> We believe that lack of knowledge due to differences between countries with regard to, for example, language and culture, is an important obstacle to decision making connected with the development of international operations. We would even say that these differences constitute the main characteristic of

[33] Work on organization-level learning by Cyert and March ([1963] 1992) is another key theoretical building block for the model, but because the notion of experiential knowledge can arguably be seen to play a greater role in how information acquisition is seen to function in this perspective it is this latter notion that is focused upon here. This is also sensible because in Cyert and March's theory focus is on organization-level learning rather than on individual-level learning, while it is the latter type of individual-level learning that the Uppsala Model has come to emphasize. Forsgren (2001) highlights this in his analysis of the Uppsala Model, noting that one of the core assumptions in this perspective is that knowledge is highly dependent upon individuals and therefore difficult to transfer to other individuals and other contexts.

> international, as distinct from domestic, operations. (Johanson and Vahlne 1977: 26)

A basic assumption of the Uppsala Model is that lack of knowledge about foreign markets is a major obstacle to international operations. This lack of knowledge creates uncertainty, which correlates positively with psychic distance (defined as factors that make it difficult to understand the target market). In other words, a company from Sweden would have lower psychic distance, and therefore less uncertainty, in relation to Finland than in relation to China. However, the model posits that uncertainty can be overcome by acquiring knowledge. The most important kind of knowledge for overcoming uncertainty created by psychic distance is said to be experiential knowledge. Johanson and Vahlne drew the notion of experiential knowledge from the distinction made by Penrose ([1959] 1995) between "objective knowledge" and "experiential knowledge." Penrose described these as follows:

> Knowledge comes to people in two different ways. One kind can be formally taught, can be learned from other people or from the written word, and can, if necessary, be formally expressed and transmitted to others. The other kind is also the result of learning, but learning in the form of personal experience. ... The first form is what might be called 'objective' knowledge. ... (The) second form in which knowledge appears (is) ... the form I have called experience. ... Experience produces increased knowledge about things and contributes to 'objective' knowledge in so far as its results can be transmitted to others. But experience itself can never be transmitted; it produces a change - frequently a subtle change - in individuals and cannot be separated from them. (Penrose [1959] 1995: 53)

Johanson and Vahlne argue that it is this latter kind of knowledge, experiential knowledge, which is critical for the international growth of the firm because it is less easy to acquire than what they call "explicit information" or "objective knowledge":

> We believe that this experiential knowledge ... is critical because it cannot be so easily acquired as objective knowledge. In domestic operations, we can to a large extent rely on lifelong basic experiences to which we can add the specific experiences of individuals, organizations and markets. In foreign operations,

> however, we have no such basic experiential knowledge to start with. It must be gained successively during the operations in the country. (Johanson and Vahlne 1977: 27)

Hence, experiential knowledge is specifically—as the name implies—tied up with experience, so that such knowledge must be acquired by a firm mainly through own operations abroad (Johanson & Vahlne, 1977, 1990). Therefore, in this model, information is seen to be acquired primarily through activity in foreign countries in a gradual process of learning-by-doing, in which the firm becomes closely connected to foreign markets (Forsgren, 2001).

Johanson and Vahlne updated their model in 2009 (Johanson & Vahlne, 2009). In the newer version, the business environment is viewed as a network of relationships rather than as a neoclassical market with many independent suppliers and customers. Outsidership in relation to the relevant network is considered the primary root of uncertainty rather than psychic distance. However, from the point-of-view of information acquisition, there is little change:[34] in the updated model, the only change to the argument concerning knowledge is the assertion that new knowledge is developed in relationships. As Johanson and Vahlne put it:

> Given the business network view, we add to our model the concept of relationship-specific knowledge, which is developed through interaction between the two partners, and that includes knowledge about each other's heterogeneous resources and capabilities. ... The interaction between a buyer's user knowledge and a seller's producer knowledge may also result in new knowledge. (Johanson & Vahlne 2009: 1415-1416)

Another slight change to the model in the newer version is the assumption that some types of knowledge are only accessible to network insiders. Hence, a strong commitment to partners is said to allow firms to build on their respective bodies of knowledge and to discover and/or create opportunities. The speed, intensity, and efficiency of the processes of learning, creating knowledge, and building trust depend on existing knowledge, trust, and commitment, as well as on the extent to which partners find given opportunities appealing. This is also given as the reason why international new

[34] Here the updated model is examined only from the point-of-view of information acquisition. The 2009 revised Uppsala Model also changes the view of the pattern of international expansion from being determined by psychic distance to being determined by opportunities as seen by network partners.

ventures may grow very rapidly: the founding entrepreneur may already have access to knowledge and relationships prior to beginning international growth.

This perspective to information acquisition in international business implies that a small company should focus on learning through experience and through business relationships.[35] This would imply that a firm should not aim to acquire information—in the sense of "explicit knowledge"— but rather aim to gain experiential knowledge through learning-by-doing. Such learning-by-doing would comprise both the establishment of own operations and the building of business networks in different countries. These processes can be accelerated by capitalizing on the experiential knowledge and relationships that central individuals in the firm may have from their previous lives, i.e., from their time prior to joining the firm.[36] However, small firms cannot only rely on their previously existing knowledge and relationships, as successful innovation requires constant learning and new knowledge (Katila, 2002; Katila & Ahuja, 2002). The information acquisition mechanisms described in this perspective—establishing own operations abroad and developing close, committed network relationships in various countries—require considerable resources, something that small firms do not have. Therefore, this perspective leaves open the question of how small firms in international business can acquire information in the international marketplace, given their very limited resources.

2.4.3 Tacit Knowledge Transmission and Conversion

The third perspective to examining information acquisition that may be identified in international business studies arose in the 1990s and can be characterized as emphasizing the importance of tacit knowledge and aiming to explicate the mechanisms of its transmission and conversion into explicit knowledge. There are two variations of the argument in this perspective, one by Kogut and Zander (Kogut & Zander, 1992, 1993), and one by Nonaka et al.

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[35] Although it is acknowledged in this perspective that experiential learning may already have been built up prior to the establishment of the firm. Therefore, the firm is not constrained to only that information acquisition which takes place after its founding, but can benefit from the experiential knowledge and relationships that the central individuals (primarily, the founding entrepreneur) have gained prior to beginning this particularly business. Additionally, it is assumed in this perspective that the more experiential learning and relationships a firm has at a given point in time, the better it can build up new experiential learning.

[36] Indeed, the recently emerging field of international entrepreneurship has confirmed that information acquisition is enhanced by a new venture's embeddedness in international business and social networks (Lindstrand, Melen, & Nordman, 2011; Presutti, Boari, & Fratocchi, 2007).

(Erden, von Krogh, & Nonaka, 2008; Nonaka, 1994; Nonaka & Konno, 1998; Nonaka & Takeuchi, 1995; Nonaka & Toyama, 2003). However, both of these variations largely build on common ground as they draw on artificial intelligence and cognitive science, making it sensible to examine them together.

Kogut and Zander (1992, 1993) define tacit knowledge as experiential and embedded in shared values and assumptions. It is, they claim, distinct from information, which they describe as explicit and restricted to describing factual statements about states of the world (Kogut & Zander 1993: 631). Kogut and Zander posit that tacit knowledge and information closely approximate notions of procedural and declarative knowledge in artificial intelligence, respectively. Hence, Kogut and Zander equate tacit knowledge with procedural knowledge that consists of statements that describe a process (Kogut & Zander 1992: 310). They call this tacit, procedural knowledge accumulated practical skill and expertise. More specifically, they characterize tacit knowledge as uncodified, experiential, incrementally accumulated, high complex, and embedded in shared values and assumptions. As such, it is very challenging to transmit, because its transmission requires shared values, assumptions, and codes between senders and receivers, which come into being only through experience over time. This is different from information, which Kogut and Zander claim can be "transmitted without loss of integrity once the syntactical rules required for deciphering it are known" (Kogut & Zander 1992: 310).

Tacit knowledge is so difficult to transmit, Kogut and Zander continue, that it cannot be transmitted through markets even if markets worked perfectly. Instead, it is transferred better within a firm. This is because a firm is a social community with shared values and assumptions, in which individuals, through repeated interactions, have developed common understanding of how tacit knowledge is coded and communicated, thus making its transmission possible (Kogut and Zander 1993: 627). In other words, according to Kogut and Zander, a firm has standardized procedures that are an expression of shared knowledge, values, and assumptions, and which ease the transmission of tacit knowledge within the firm. In other words, a firm is a "repository of social knowledge that structures cooperative action" (Kogut and Zander 1993: 627). The advantage of such a community with shared values, assumptions, and codes is said to be particularly valuable when tacit knowledge needs to be transmitted across national borders. Consequently, Kogut and Zander claim that the multinational corporation

arises because it has superior abilities for the transmission tacit knowledge across national borders.

Nonaka, with various co-authors (Nonaka, 1994; Nonaka & Takeuchi, 1995; Nonaka, Toyama, & Byosière, 2001; Nonaka, Toyama, & Konno, 2000; Nonaka, von Krogh, & Voelpel, 2006), has developed a very similar argument. In a foundational paper, Nonaka (1994) put forth two main premises: (1) tacit and explicit knowledge can be conceptually distinguished along a continuum; and (2) knowledge conversion explains the interaction between tacit and explicit knowledge that leads to the creation of new organizational knowledge. Building on artificial intelligence in the same manner as Kogut and Zander, Nonaka et al. claim that what he calls "explicit knowledge" is knowledge about past events or objects and oriented toward context-free theory. It can be created in a sequential manner, easily processed by a computer, transmitted electronically, and stored in databases (Nonaka & Takeuchi 1995: 8-9). By contrast, tacit knowledge is "highly personal and hard to formalize (including) subjective insights, intuitions, and hunches (that are) deeply rooted in an individual's action and experience, as well as in the ideals, values, or emotions he or she embraces" (Nonaka & Takeuchi 1995: 9). Tacit knowledge, according to Nonaka et al., is created in social interactions rather than by an individual operating in isolation (Nonaka et al., 2000). Moreover, it is created in the "here and now" in a specific, practical context of emerging relationships and practices of a group (*Ba*) (Nonaka & Konno, 1998; Nonaka et al., 2006).

Tacit knowledge, Nonaka et al. posit, exists at the individual level and group level (Nonaka, 1994). Individual-level tacit knowledge "resides" in individuals and is therefore difficult to externalize. Group-level tacit knowledge is embedded in group culture, norms, and routines, and rooted in commitment, ideals, values, senses, and emotions (Nonaka & Takeuchi, 1995). Group culture gives rise to group identity, group language, definition of group boundaries, and a feeling of shared belonging. All of these emerge as a result of shared experiences and lead to collective sense-making (Erden et al., 2008). Like Kogut and Zander, Nonaka et al. assert that tacit knowledge is difficult to transmit. According to Nonaka et al., the transmission of tacit knowledge requires local, face-to-face, "here and now" interaction of people in small groups (Nonaka, 1994; Nonaka & Konno, 1998; Nonaka et al., 2006). Group-level tacit knowledge facilitates the transmission of individual-level tacit knowledge, as it makes it possible for group members to act in a coordinated manner, solving complex tasks without explicit rules for action, or even without explicit communication. This shared understanding enables the transmission of tacit knowledge between group members.

However, tacit knowledge must be converted into explicit knowledge if it is to be transmitted beyond the local interactions of the small group with its common culture, norms, routines, and collective sense-making. Indeed, Nonaka et al. argue that conversion between tacit and explicit knowledge types constitutes the knowledge creation spiral. There are, according to Nonaka et al., four modes of knowledge conversion (Nonaka 1994: 339) that together constitute the SECI (Socialization, Externalization, Combination, Internalization) model (Nonaka, 1994; Nonaka & Takeuchi, 1995; Nonaka et al., 2000). The first mode of knowledge conversion, Socialization, is that of "tacit knowledge to tacit knowledge." In this mode, tacit knowledge is communicated through interaction between individuals without necessarily involving language but rather by observation, imitation, and practice. The key to acquiring and communicating tacit knowledge is experience, and especially shared experiences, which enable individuals to share their thinking processes. The second mode of knowledge conversion, Externalization, involves conversion of tacit knowledge into explicit knowledge. The third mode, Combination, is that of "explicit knowledge to explicit knowledge" and involves the use of social processes to combine different bodies of explicit knowledge held by individuals. Finally, the fourth mode of knowledge conversion, Internalization, is similar to the traditional notion of learning. These four modes constitute the spiraling knowledge processes of interaction between explicit knowledge and tacit knowledge that results in the creation of new organizational knowledge.

This perspective to information acquisition in international business implies that a small company should pay special attention to the processes of creating, transmitting, and converting tacit knowledge. However, for a small company that needs to acquire much of its information externally, this presents a special challenge as it is unclear how it might be able to acquire tacit knowledge from outside its organizational boundaries. This is because this perspective holds that tacit knowledge is best created and transmitted within small groups and firms as such communities have common cultures, values, and assumptions that make tacit knowledge transmission possible. Therefore, it seems that according to this perspective, a small company looking to acquire information from external sources would only have access to explicit knowledge. Moreover, small firm size would seem to pose limits to how much tacit knowledge can be created in the firm. Therefore, according to this perspective, small firms would be quite disadvantaged as it is implied that the amount of tacit knowledge that they create internally is limited by their size and the information they acquire externally is limited to explicit knowledge.

Since this perspective emphasizes the importance of tacit knowledge, it leaves open the question of how small firms can acquire information in international business that would allow them to be competitive.

2.4.4 Social Learning in Communities and Networks of Practice

The fourth perspective that may be identified in international business studies views information acquisition as social learning in communities and networks of practice. This perspective may be characterized as the most recent and least developed in international business studies. It has been developed principally by Tallman et al. (Tallman & Chacar, 2011; Tallman & Fladmoe-Lindquist, 2002; Tallman, Jenkins, Henry, & Pinch, 2004), building on work by Brown and Duguid (1991, 2001) and by Lave and Wenger (1991), to examine how a multinational corporation can source knowledge from multiple locations around the world.

The argument begins from the premise that all knowledge has some tacit aspects, rather than knowledge being of two types (tacit and explicit). However, knowledge is said to have differing degrees of tacit content. Focusing on knowledge high in tacit content, Tallman et al. (2011), building on Brown and Duguid (2001), propose that the mechanisms of acquiring external knowledge with a high tacit content can be understood and studied best at the micro-organizational level of communities of practice and the networks of practice that they form. In line with Brown and Duguid (2001), Tallman et al. (2011) define a community of practice as a small, focused group of physically co-located individuals within an organization who are joined by being engaged in the common practice of some activity. Through their joint practice of some activity in close physical proximity, individuals in a community of practice develop shared language, culture, and values. Individual learning is, in this perspective, seen to take place through practice of some activity that enables a deep understanding of that activity. Hence, the individual develops knowledge not only of the overt, explicit actions that are required but also of the architecture of the activity that constitutes the essence of tacit knowledge (Henderson & Clark, 1990; Polanyi, [1966] 1983).

Engagement in practice takes place in a context of social relationships by learning from others through observation, imitation, and modeling. Hence, learning is largely about becoming part of a community of practice by internalizing the group's shared language, culture, and values (Lave, 1988; Lave & Wenger, 1991). By participating in a community of practice, an individual is able to learn what Tallman et al. (2011) call "component

knowledge": the common operational and technological knowledge that the members of the group have developed through joint practice. Members of a community of practice also develop what Tallman et al. call "architectural knowledge": common repertoires of behavior, perspectives on, and understandings about the system of knowledge development and application (Frost & Zhou, 2005; Henderson & Clark, 1990; Matusik & Hill, 1998; Tallman et al., 2004). This architectural knowledge is internalized by participating in the experience of the common practice and provides the understanding to absorb related component knowledge effectively. In other words, it is the undergirding that makes component knowledge sensible.

When several communities of practice engaged in similar activities exist in a confined geographical area, this is said to lead to the creation of networks of practice. These networks of practice are composed of interacting communities of practice from different organizations in a local geographic region or cluster (Brown & Duguid, 2001; Storper, 1993; Tallman et al., 2004). Thus, in a local cluster, each community of practice is immersed in a local network of practice that is composed of several communities of practice from multiple organizations. These networks of practice, and the social ties they represent, promote the development of network-level architectural knowledge that eases the transmission of tacit component knowledge among embedded member communities of practice (Brown & Duguid, 1991, 2001; Tallman et al., 2004). Consequently, this perspective proposes that the creation and movement of valuable tacit knowledge across firms is tied closely to practices that exist in specific geographic locations.

Therefore, co-location is argued to be necessary for the emergence of communities and networks of practice. This is because it is posited that dense communication, claimed to be essential to knowledge exchanges, breaks down over even a short distance. In other words, knowledge flows are assumed to be highly localized. However, while co-location may be necessary for local knowledge acquisition, it is by no means sufficient (Tallman et al., 2004). Instead, a degree of participation and experiential learning is essential to learning. This is because only those individuals engaged in the joint practice of some activity in communities and networks of practice gain the deeper architectural knowledge that eases the transmission of component knowledge, especially when it is highly tacit. Therefore, when members of co-located communities of practice engage in common practices, interactions, and mutual involvement in activities in local networks of practice, they gain the ability to acquire experiential and vicarious learning through formal and informal inter-firm networking (Grandori, 2001). This makes it possible to exchange stocks

and flows of more or less tacit component knowledge among nearby communities of practice (Tallman et al., 2004). This is because, it is posited in this perspective, nearby communities work on similar issues and are composed of similar individuals who have similar training and objectives and share professional norms (that is, share common architectural knowledge) (Faulconbridge, 2008). Thus, they will have high absorptive capacities for component knowledge coming from each other and knowledge will flow easily across a network of practice (Tallman et al., 2004). Physical proximity offers the added benefits of shared local norms, language, and culture, as well as national norms and culture (Ouchi, 1980). Likewise, the movement of knowledgeable individuals from firm to firm, a largely local phenomenon (Almeida & Kogut, 1997), builds social networks and leads to knowledge spillovers (Rosenkopf & Almeida, 2003) that offer value within relevant communities.

This perspective strongly emphasizes that communities and networks of practice are local. This is posited to be because of the importance of rich, face-to-face communication to transmit tacit knowledge (Pedersen, Petersen, & Sharma, 2003). Thus, distance—whether geographical, institutional, or cultural—will make knowledge transmission more uncertain (Kogut, 2007; Szulanski, Jensen, & Lee, 2003). This is held to be largely because the different architectures of knowledge developed in distant communities and networks reduce absorptive capacity for component knowledge across both geographic and practice boundaries (Tallman et al., 2004). This relates to the assumption that communities and networks of practice create shared cultures and group identities, and that the local communities and networks of practice are strengthened by shared cultural and institutional ties at a higher level (Bell & Zaheer, 2007).

This perspective to information acquisition in international business implies that a small company should participate in various local networks of practice around the world. It would need to become involved, over time, in the mutual activities of these physically co-located networks of practice in order to learn the architectural knowledge, which would enable the acquisition and absorption of component knowledge. However, as networks of practice are said to be closely tied to specific geographic locations, with communication breaking down over even short distances, this would mean that a company wishing to acquire a diversity of information would need to be present in several locales around the world at once. Moreover, it is stressed in this perspective that learning of the architectural knowledge necessary to acquire and absorb component knowledge takes place in active participation in mutual

practices of the network over time, which would seem to require substantial resources on the part of a company looking to acquire information in several locales internationally. It is unclear how a small company could stretch its meager resources to participate actively in practices in multiple localities around the world, or whether it would be limited to information available only in one or two locales. Therefore, this perspective leaves open the question of how a small firm in international business can acquire information from around the world.

2.4.5 Conclusion

The theoretical perspectives on information acquisition in international business studies all offer valuable insights. However, they have been developed primarily to explain information acquisition (or, rather often, simply internal information transmission) by large multinational corporations. This limits the applicability of these theories to small firms operating in the international marketplace. The exclusive focus on large multinational corporations is particularly evident in the first and third perspectives, those of information transactions and tacit knowledge transmission, which quite explicitly argue for the superiority of large multinational corporations as international information transmission vehicles. The rationales provided for this argument differ between the two perspectives, with opportunism, cheating, and free riding emphasized in the information transactions perspective and the importance of community and shared codes emphasized in the tacit knowledge transmission perspective. Nonetheless, the core argument is the same in the two perspectives: the multinational corporation as an organizational form is advantaged when it comes to international transmission of information. Neither of these perspectives explicitly addresses acquisition of information from external sources in the international marketplace. Therefore, these perspectives leave unanswered the question of how a small firm can acquire information in international business. Particularly, as a small firm must rely extensively on external information acquisition, the implicit conclusion that can be drawn from these perspectives is that the small firm is severely disadvantaged, as it is vulnerable to cheating, opportunism, free riding, and has trouble transmitting tacit knowledge as it lacks a sizeable international community. Even if this conclusion is not drawn, these perspectives shed very little light on information acquisition by a small firm in international business, although the network argument appended to the information transactions perspective may be a move in this direction.

Even when the argument of the advantage of large firm size is not made explicitly, the described mechanisms for information acquisition appear to require sizeable corporate resources. This can be seen in the second and fourth perspectives, those of experiential learning and social learning. In the experiential learning perspective, information acquisition is argued to take place by a firm establishing own operations abroad and/or by establishing close, committed relationships with network partners in foreign countries, both processes that require substantial resources. It is unclear how a small firm, which is unlikely to have the resources required to establish own operations in multiple countries or to foster and maintain multiple close, committed business network relationships, can acquire information in the international marketplace. The implicit conclusion that can be drawn from this perspective is that a small firm is restricted to acquiring information only from those few markets and business network relationships that it has had the resources to enter. In the social learning perspective, information acquisition is described as taking place through active participation over time in networks of practice in multiple locales around the world, which also demands sizeable resources on the part of the firm. Like the experiential learning perspective, this perspective also seems to indicate that a small firm is restricted to acquiring information only from those few locales in which it has the resources to be present and active. Therefore, these perspectives leave open the question of how a small firm, with very limited resources, is able to acquire information simultaneously from several markets around the world as it cannot have own operations, close network relationships, or active participation in local networks of practice in more than a few markets.

In sum, because the theoretical perspectives in international business studies that can be used to examine information acquisition have been constructed with rather large firms in mind, they are not readily applicable to small firms. These perspectives either emphasize the benefits of large firm size or, at least implicitly, call for substantial corporate resources. As a small firm possesses neither, it remains unclear how a small firm can acquire information simultaneously from multiple markets around the world. Yet, to create and commercialize innovations, small firms need to be able to acquire information from several international markets. This information acquisition is unlikely to consist of simple and straightforward processes, as small firms rely on this information acquisition for their core innovative competitive advantages. It may be that theory construction on information acquisition in international business by small firms has been slowed down by the challenging nature of gathering data in small firms. Overstretched managers in small firms may be

averse to giving time to matters not centrally related to the firm's interests and may be reluctant to answer questions on sensitive matters relating to innovation to an outsider. Nonetheless, the importance of small firms has been recognized already in international business studies, as well as the criticality of information acquisition in their operations. It is imperative that research now begin uncovering the ways and means of information acquisition by small firms in international business.

3 METHODOLOGY

This chapter presents the methodology used in the empirical study conducted to answer the research question of *"How does a small firm acquire information for innovation in international business?"* It starts by describing the chosen research site where the empirical study was conducted and by clarifying the justification for this choice as well as means of accessing this research site. It then explicates the data collection for the study, reviewing both the methods used and their implementation. Finally, the data analysis carried out for the study is described, again reviewing both the methods used and their implementation. As such, this chapter forms the basis for the following chapter, in which the results from the empirical study are presented.

3.1 RESEARCH SITE

3.1.1 Research Site Description

The empirical research for the study was conducted at the research site of a dedicated biotechnology firm in Finland, referred to in this study by the pseudonym "FinnBiotech" because of the company's wish to remain anonymous. FinnBiotech is a Finnish privately-owned dedicated biotechnology firm with 40 employees that develops, manufactures, and markets rapid immunodiagnostic tests for use in human and animal healthcare as well as food hygiene. It is located in the metropolitan region of Finland's capital city Helsinki, which is home to most of Finland's biotechnology activity. FinnBiotech was founded in 1986 by three entrepreneurs who brought with them expertise from academia, business, and entrepreneurship: all three of the founders held PhDs in areas related to human and animal health and had previously collaborated in founding other entrepreneurial ventures in areas related to human and animal health.[37] The founder who assumed the position of FinnBiotech's Managing Director also came with experience in business beyond entrepreneurship, having held the

[37] The founders as well as all other individuals will remain unnamed here because of their own wishes to remain anonymous in order to maintain a degree of confidentiality concerning their business activities.

position of R&D Manager at Finland's only large diagnostics company immediately prior to founding FinnBiotech.

FinnBiotech develops, manufactures, and markets rapid immunodiagnostic tests for cardiac, fertility, gastroenterology and infectious disease biomarkers mostly for use in human healthcare, but also in animal healthcare and food hygiene. Rapid immunodiagnostic tests are low-cost, simple to operate and read, sensitive, specific, stable at high temperatures, and work in short periods of time. They are a type of point-of-care diagnostic, meaning that these tests are intended to provide diagnostic results conveniently and immediately to the patient while still at the health facility, screening site, or other health care provider. Indeed, rapid tests can be used in a variety of settings, from primary care clinics and emergency rooms to doctors' offices and patients' homes. While the majority of tests are still performed in highly automated and advanced hospital laboratories, point-of-care rapid tests are becoming increasingly critical in healthcare systems of both developed and developing countries. This is because they reduce dependence on central laboratories, which in turn helps to improve patients' quality of life and alleviates some of the major problems facing healthcare systems in both developed and developing economies. Immunochromatographic tests, such as those developed, manufactured, and marketed by FinnBiotech, are particularly well suited for use in a variety of settings outside of central laboratories because they are the simplest type of rapid diagnostic test. They require only minimal familiarity with the test and no equipment to perform, since all of the reactants and detectors are included in the test strip. The simplicity and ease-of-use of these tests allows them to be used at home or by minimally trained healthcare workers.

Point-of-care testing and patient self-testing have significant advantages for both patients' quality of life and the healthcare system at large. Receiving diagnosis at the point of care reduces the need for multiple visits to receive diagnostic results, thus improving the specificity of diagnosis and the chances the patient will receive treatment, reducing dependence on presumptive treatment, and reducing the risk that the patient will get sicker before a correct diagnosis is made. Correct early diagnosis results in a more efficient cycle of treatment for the patient and a more efficient healthcare system in general, benefiting the individual and society as a whole. Early diagnosis, in particular, can ensure that the patient begins either immediate medical treatment or necessary lifestyle/dietary adjustments, in many cases before physical symptoms of illness begin to manifest themselves, thus avoiding unnecessary pain and suffering. Examples of illnesses in which early

diagnosis is crucial for patient recovery are numerous, including various forms of cancer where treatment can be pinpointed accurately through diagnostics to guarantee the best possible healthcare result. The benefits of rapid tests also extend to long-term illnesses and chronic conditions. Rapid tests can be utilized regularly to monitor the patient's medical state and to adapt treatment as necessary in a timely and safe manner. This precise monitoring enables patients and their medical practitioners to make well-informed decisions that will help save precious resources for healthcare systems and expand a patient's lifespan and quality of life. Rapid tests are utilized also in the field of public health, where general screenings work to maximize diagnoses and designate appropriate treatment where necessary.

Apart from the enormous contribution to patients' quality of life and improved cycle of treatment, rapid tests also provide many economic benefits to national healthcare systems. In developed economies such as the United States and Europe, the ability of rapid immunodiagnostic tests to provide diagnostic results conveniently and immediately to the patient while still at the health facility, screening site, or other healthcare provider can help contain escalating healthcare costs (Carlson, 2009). Allowing earlier and more appropriate treatments shortens the length of hospital stays, rules out expensive treatments, and reduces costs for the treatment of complications. Rapid diagnostic tests also reduce the need for multiple visits to receive diagnostic results, which is a major benefit especially for patients in poor condition, and saves healthcare staff's time.

In developing economies, rapid tests can alleviate the shortcomings of healthcare systems where large portions of the population have, at best, access to poorly-resourced healthcare facilities with almost no supporting clinical laboratory infrastructure (Yager, Domingo, & Gerdes, 2008). Rapid tests are particularly important in low-resource settings, where harsh environmental conditions combined with limited access to electricity and refrigeration preclude the use of sensitive equipment, technology, and equipment required for more complicated laboratory tests, and many patients cannot travel easily to the clinic to follow up on results that take a long time. Moreover, because rapid tests can be used by minimally trained healthcare personnel, such as community health workers, they can be used to provide diagnosis even when highly trained medical personnel are lacking. Indeed, fueled by government health insurance initiatives and extension of healthcare infrastructure to rural communities, countries like Brazil, Russia, India, and China are experiencing high growth rates for rapid diagnostic tests (Rosen, 2011).

FinnBiotech develops and manufactures rapid immunodiagnostic tests at its facilities in Helsinki's neighboring town of Vantaa, close to Finland's largest international airport. At this facility, the company's employees conduct R&D in order to develop both new generations of existing tests and entirely new tests, adapt them for mass production, and carry out this mass production. Additionally, the company's management, administration, legal department, and marketing department are housed in this building. However, the overwhelming majority of the 40 people who work there are involved in production. This location is highly convenient, because FinnBiotech exports over 93% of its production as airfreight to customers in over 50 countries.

FinnBiotech's customers are specialized diagnostic and pharmaceutical companies worldwide as well as distributors serving these companies, meaning that FinnBiotech operates in the business-to-business market. End customers—hospitals, doctors' offices, pharmacies—purchase FinnBiotech's products from intermediaries, often under a brand other than FinnBiotech, with FinnBiotech acting in these cases in the role of a sub-contractor/OEM. FinnBiotech's largest markets are Europe, Asia, Middle East, and Africa, with South American demand fluctuating and the North American market difficult to break into fully because of regulatory issues. In addition to production in Finland, FinnBiotech has strengthened its production capabilities by building a factory in South Korea in a joint venture in 2000–2001 and by entering a joint venture with an Indian medical technology manufacturer in 2012 to build a factory in India. These moves have helped it to meet better the needs of customers around the world as well as respond to growing demand. FinnBiotech also diversified its production in 2008, when it acquired the operations of an ELISA test kit manufacturer located in Finland (albeit owned by a multinational corporation based in the United States), and merged them with its existing operations in Vantaa.

FinnBiotech remains privately owned by its founders. It has financed its operations primarily with bank loans and revenue income. This has been possible because FinnBiotech started out with a product that could be commercialized quickly to generate profit, which could be reinvested into the company. Since FinnBiotech's business began flourishing, several venture capitalists both from Finland and abroad have been interested in investing in the company, but the founders have not wanted to give up ownership because they have wanted to maintain control of their company. This financing model has meant that FinnBiotech's growth has been somewhat modest, reflecting its management philosophy of proceeding in a careful and controlled manner. However, with this management philosophy, FinnBiotech has managed to stay

alive and profitable for well over two decades, a feat that a significant portion of Finnish dedicated biotechnology companies have failed to accomplish. FinnBiotech, together with its acquired ELISA test kit operations, has been generating annual revenue of about €7 million for the past years, with healthy profit margins of around 20%. This can be considered an impressive accomplishment in the Finnish biotechnology sector, where a large number of biotechnology companies continue to be loss-making operations dependent on government support, having been unable to create profitable business from their R&D activities.

3.1.2 Choosing and Accessing the Research Site

Two characteristics of FinnBiotech formed the main decision criteria for choosing it as a research site for the study: its high experience levels of having been operational for over two decades and the fact that it has accomplished the rather rare feat of being profitable for nearly all of that time. Both of these facts are quite unique in the Finnish biotechnology sector, where most firms were only founded in the 1990s and have yet to attain profitability, and it is not known if they ever will reach profitability and become viable business ventures. Most of these firms are still in the stage of conducting R&D, with no products in the market. Therefore, since the objective in this study was to examine processes underlying innovations, not inventions, it was necessary to find a research site that had been able to turn inventions into innovations.

Moreover, a desirable research site was one where homogeneity of context could be controlled by conducting the study within a single research site. Controlling the context makes it easier to draw reasonable conclusions as the multitude of alternative explanations is minimized (Van de Ven & Poole, 2002). However, at the same time, it was highly desirable to be able to include variation in the data by examining processes underlying both successful and less successful innovation outcomes. This research design could be realized at FinnBiotech because its high experience levels made it possible to locate a richness of data within a single research site that allowed the study and comparison of both successful and less successful innovation outcomes while controlling the context. In short, FinnBiotech's success and history made it a fertile ground from which to draw a heterogeneous sample that allowed comparison while maintaining the context sufficiently homogeneous to keep the multitude of alternative explanations at an acceptable level. Additionally, FinnBiotech's small size meant that its internal information processes could be

assumed to be relatively simple. This permitted focusing on external information acquisition.

Accessing this site was not entirely unproblematic, as the study proposed to examine processes that were close to the core of the business and therefore something that most businesses in this sector wished to keep secret. It is for this reason that the company is referred to in this study by a pseudonym and no individual names are revealed, as this could provide the company at least some confidentiality. Access to the site was negotiated through social networks, as FinnBiotech's Managing Director was a close family friend of the author of this study. Indeed, it is uncertain whether there would have been awareness of FinnBiotech had it not been for this connection because FinnBiotech is a rather media-shy company known only to industry insiders. As it is privately owned, it is not required to publicize much about its operations, and as its owners have little interest in appearing in the financial media, it may be considered something of a hidden gem. Therefore, informal information networks were very valuable for this research, having raised awareness of FinnBiotech's existence and making it possible to negotiate access to this research site in order to conduct the study.

3.2 DATA COLLECTION

3.2.1 Interviewees

Data collection at FinnBiotech focused on the individuals of the management team. This choice was motivated by initial research at FinnBiotech, which made it clear that because of the company's small size, its knowledge management activities were informal. There is no formal organization or system for knowledge management. This is because the company only employs 40 employees, all of them at the same physical facility in Vantaa, and with the overwhelming majority of them involved in production. While this work undoubtedly involves knowledge, these individuals do not cross organizational boundaries in their work activities or deal with external knowledge, which was the focus in this study. Indeed, it turned out in the initial research that boundary-crossing activities involving external knowledge are quite completely concentrated on the individuals of the management team. The choice to focus on the individuals of the management team, which was motivated first by initial empirical data, was supported also by theoretical

arguments. It has been posited that the management team is the main interface between the firm and its environment (Hambrick, Finkelstein, & Mooney, 2005). The individuals in the management team are important "boundary spanners" (Tushman, 1977; Tushman & Katz, 1980; Tushman & Scanlan, 1981) who play a critical role in the knowledge processes between the organization and its environment (Child & Heavens, 2001).

The management team at FinnBiotech comprised six individuals at the time of the study. The Managing Director was one of the three initial founders, having been active in the company throughout its existence. He was the main contact of the firm to the outside world and had overall responsibility within the organization. The other five management team members had joined the company after its founding, with tenures ranging from 24 and 23 years on the longer end to 15 and 13 years on the shorter end. Thus, the management team members had all been with the company for relatively long career spans. The management team members were all Finnish, with educational backgrounds predominantly in fields related to the life sciences. There was, however, some diversity in educational backgrounds, as they included veterinary medicine, molecular biology, agricultural and forestry marketing, and biochemistry. Four of the management team members were male and two female. While the Managing Director had overall responsibility and was quite involved in all areas of management team work, the other five management team members had specific areas of responsibility, these being R&D, export marketing, quality, production, and production technology. The titles of the management team members were thus: (1) Managing Director (male, PhD in veterinary medicine), (2) R&D Manager (male, M.Sc. in molecular biology); (3) Export Manager (male, M.Sc. in agricultural and forestry marketing), (4) Quality Manager (female, M.Sc. in biochemistry), (5) Production Manager (female, M.Sc. in biochemistry), and (6) Technical Manager (male, M.Sc. in machine engineering).

The management team was co-located at the facility in Vantaa and closely worked together, and appeared to share information very actively and openly with each other both formally and informally. Therefore, in this particular small company setting, knowledge activities by individuals could be seen to be largely synonymous with knowledge activities by the firm, making it possible to focus on the concrete activities of individuals when examining external information acquisition for innovation. Enforcing this could be seen to be the role and personality of the Managing Director, who as a company founder had been involved in all company activities throughout the company's lifespan and continued to involve himself in all of the management team

activities. He could be seen as a force binding together the knowledge activities of the rest of the management team individuals, making sure that all information was shared among all the management team individuals and thus distributed to the rest of the company. Additionally, the management team members all had long tenures in the company and seemed to have a genuine commitment to both the company and the Managing Director, which could be assumed to further support information sharing within the company as the individuals had little incentive to hoard information. Thus, as the company was small and all employees were located in the same building, interaction between all of the management team members was frequent, both formally and informally. Hence, due to the size of the organization, there were no noteworthy internal boundaries, but rather the organization's boundary with its environment was the most pronounced one. FinnBiotech's small size thus enhanced its suitability as an excellent research site for this study, as the relative lack of rigid internal organizational boundaries put information activities crossing the external organizational boundary into focus.

3.2.2 Interview Method

Interviews were determined to be the best method of data collection as they made it possible to access accounts of knowledge processes from the actors' points of view. As Flick (2006) notes, when examining reflexive actions such as those involving knowledge, it is essential to view them from the individuals' subjective viewpoints as these provide the bases for action. This approach to data collection was also in line with grounded theory methodology, which tends to be best suited to micro-level analysis where the aim is to understand actors' subjective and intersubjective views. The specific interview method used was that of episodic interviewing, a variety of the semi-structured interview method developed by Flick (1997, 2000), which seeks to exploit the advantages of both the semi-structured and narrative interview types. It does this by including in the research question guide both questions that query semantic knowledge that is more abstract, generalized, and decontextualized from specific situations, and narrative-episodic knowledge that is linked to concrete circumstances (time, space, persons, events, situations). Gathering both generalized knowledge and narratives appeared to be the most productive approach because this was largely in line with how the interviewees recounted their views and experiences. Indeed, they provided narratives as examples to illustrate and clarify general statements unprompted in the early interviews,

which led to the decision to query the interviewees for more narratives as these appeared to illuminate powerfully the dynamics under study.

Although collecting narratives is considered a technique that is sensitive and responsive to the interviewees' viewpoints, invitations for narratives also require interviewer input. Narrative interviewing involves the paradox of the researcher giving up control while being well prepared to ask good questions that will invite the other's stories. Thus, while questions are open-ended and the narratives listened to with "a minimum of interruptions," a "generative narrative question" is needed to stimulate narratives (Flick, 1997, 2000). This generative narrative question needs to be formulated broadly but at the same time sufficiently specifically for the interesting experiential domain to be taken up as a central theme. Thus, while it is crucial for the quality of the data that the narrative is not interrupted or obstructed by the interviewer, the generative narrative question needs to provide the narrator with sufficient material and prompts to focus the narrative on the topical area with which the interview is concerned. The generative narrative questions as well as questions used to query semantic knowledge are presented next.

3.2.3 Interview Rounds and Themes

All six members of the management team were interviewed multiple times in order to collect the full richness of data that could be gathered at this research site. Moreover, carrying out the interviews in a sequential manner made it possible to make full use of grounded theory methodology principles of constant comparison and theoretical sampling. Hence, it was possible to conduct data gathering "in a self-correcting, analytic, expanding process (where) early leads shape data collection (to) form a stronger basis for creating a nuanced understanding of social processes" (Charmaz 2001: 682). Interviews were conducted in four interview rounds, with slightly different interview themes focused upon in each round.

The interviewees were sent an e-mail prior to each interview that outlined the main goals of the research and the specific interview themes that were to be focused upon. The communications sent to interviewees prior to the interviews, and repeated at the beginning of each interview, will be described in conjunction with the description of each interview round. All interviewees were Finnish and the interviews were conducted face-to-face by the author of this study in Finnish at FinnBiotech's facilities in Vantaa. All of the interviews were recorded with the permission of the interviewees and the recorded interviews transcribed in Finnish. Additional notes were taken by hand during

the interviews and used to supplement the transcriptions. The transcriptions were sent to the interviewees for checking after the interviews and any questions that arose as a result of this were either dealt with immediately or addressed in the subsequent interviews.

The four interview rounds are described next, detailing who was interviewed and what the interview themes in each round were. The first three interview rounds took place during the years 2005–2007 while the fourth took place in 2011. Therefore, the data collection benefited from a real-time longitudinal design in addition to collecting data on FinnBiotech's history prior to 2005.

First Interview Round Themes and Questions

The first interview round consisted of four interviews with the Managing Director that lasted between three and four hours. This was necessary because not only was the Managing Director the person who made it possible to gain access to FinnBiotech but also the person with the most knowledge about FinnBiotech's activities. The Managing Director had been one of the original founders,[38] had led FinnBiotech throughout its entire history, and was involved in all of the activities carried out by the management team members. Therefore, the Managing Director was the only person capable of providing the necessary information on the historical development and overall functioning of FinnBiotech's activities. Gathering this data by way of interviewing the Managing Director was also necessary because extremely little information on FinnBiotech's general business activities existed in documented form. This was because as a private company, FinnBiotech had not needed to report publicly more than the minimum on its activities, and as a media-shy company, its activities had not been previously documented by management studies researchers or financial journalists. Certainly, in the areas where FinnBiotech needed to have documentation, especially in the areas of products and their safety, the company had extensive and careful documentation. However, this was very product-specific and mostly involved the use and handling of biological and chemical components in the products, which was not the topic of this particular study.

Therefore, because of the lack of general business activity documentation and the Managing Director's high levels of experience and knowledge, it turned out to be necessary to conduct four full interviews at this

[38] The two other founders were not interviewed because one of them had unfortunately passed away prior to beginning this study, and the other had not been involved in FinnBiotech's activities for a long time.

beginning phase in order to document all of the relevant data at this point. Prior to the interviews with the Managing Director, he was sent an e-mail describing the goal of the research, this being to gain an understanding of information acquisition activities leading to innovation at FinnBiotech. It was furthermore specified that all information acquisition activities of importance to innovation outcomes were of interest in the study, and that innovation outcomes were not considered to be only new products but also new processes, new ways of organizing, and expansion to new markets. It was noted that at this stage in the study, the interview would focus on four main themes, these being importance of information in innovation activities, the sources of information, means of acquiring information, and challenges involved in acquiring information. However, it was stressed that these were very general, open-ended themes at this stage because it was the goal of the interviews to gain as much data as possible from the point-of-view of the Managing Director, so that restricting the interview to narrow questions may have missed important points. In this way, these four interviews fulfilled the role of beginning to answer the basic grounded theory question upon entering the field of "What is happening here?" (Charmaz, 2001) while respecting the grounded theory philosophy of allowing issues to emerge from the data instead of narrowly focusing on pre-decided topics.

The first interview was very general, but provided a wealth of data. In fact, the wealth of data was so overwhelming that it was necessary to conduct a second interview on the same topics, delving deeper into those that appeared interesting, and clarifying and confirming many of the issues that had come up in the first interview. However, after the first two interviews, it was possible to focus the interview questions a bit more. Therefore, after the first two interviews, the following questions focused on the Managing Director's work tasks rather than the company overall, although it was still stressed that these were in the form of open-ended themes and should not unduly restrict the interview. These themes were:

1) Please describe your educational and professional background, both before joining FinnBiotech and at FinnBiotech.
2) Please describe your work tasks at FinnBiotech.

3) Please describe what information[39] you need and use in your work tasks at FinnBiotech, specifically focusing on external information.

4) Please describe where and how you obtain the information you need in your work tasks at FinnBiotech, specifically focusing on external information.

5) Please describe what challenges are related to obtaining and using information you need in your work tasks at FinnBiotech, specifically focusing on external information.

Again, the Managing Director was able to provide such a wealth of data that two interviews were deemed necessary in order to cover the material in necessary depth. The two interviews conducted using these interview themes followed largely the same pattern as the very first two interviews, where the second interview was used to delve deeper into interesting topics as well as to clarify and confirm issues that had been left unclear. The interviews with the Managing Director provided an initial understanding of the company, its operations, and its information acquisition dynamics. They also served to legitimize the research and to open up the possibility of interviewing the rest of the management team with the Managing Director's permission.

Second Interview Round Themes and Questions

The second interview round took place with the other five members of the management team. Each of the management team members was interviewed three times during this round. The follow-up interviews were necessary in order to delve deeper into interesting and unclear topics that had come up in the first interviews as well as making sure that the interviewees had been able to express their thoughts and sentiments in the way they wished. The interviews lasted between one to four hours.

The management team members were all sent an e-mail describing the goal of the research, this being to gain an understanding of information acquisition activities leading to innovation at FinnBiotech. It was furthermore specified that all information acquisition activities of importance to innovation outcomes were of interest in the study, and that innovation outcomes were not considered to be only new products, but also new processes, new ways of organizing, and expansion to new markets. It was also mentioned in the e-mail

[39] It should be noted that the interviews were conducted in Finnish, in which there is only a single word ("*tieto*") that denotes both "information" and "knowledge" so no distinction between the two was made in the interviews.

that the study had been approved by the Managing Director. The same semi-structured interview guide was used as had been used in the last two interviews with the Managing Director, this having the following themes:

1) Please describe your educational and professional background, both before joining FinnBiotech and at FinnBiotech.
2) Please describe your work tasks at FinnBiotech.
3) Please describe what information you need and use in your work tasks at FinnBiotech, specifically focusing on external information.
4) Please describe where and how you obtain the information you need in your work tasks at FinnBiotech, specifically focusing on external information.
5) Please describe what challenges are related to obtaining and using the information you need in your work tasks at FinnBiotech, specifically focusing on external information.

However, it was also stressed both in the e-mail and at the beginning of the interview that the interviewees were encouraged to bring up any material that they deemed to relate to the topic of information acquisition for innovation even if interview themes did not seem to directly address this material.

The fact that the interviews were set up with the backing of the Managing Director may have affected the content of the interviews, both in positive and negative ways. Positive effects may have been the greater willingness of the interviewees to be interviewed, to allocate ample time to the interviews, and to be keen to provide plenty of good interview material. Negative effects may have been that interviewees may have held themselves back from fully discussing problematic issues although all of the interviewees were assured of total confidentiality. Some hesitation in discussing problematic issues could be detected in some of the interviews, but the interviewees did choose to discuss these issues nevertheless, although in probably more diplomatic language. In general, an atmosphere featuring high levels of trust could be perceived among the management team members, even with regard to the Managing Director, as the management team members all had long tenures with the company and spoke of the Managing Director as acting over the years as an equal with the company employees. Hence, it could be assumed that the fact that the interview contacts with the management team members came through the Managing Director did not unduly inhibit the interviewees in providing data for the study. All in all, the interviews provided

a wealth of material that was openly contributed and rich with opinions, arguments, and stories.

Third Interview Round Themes and Questions

In the third interview round, all six management team members were interviewed. Each of the management team members was interviewed three times during this round, with the exception of the R&D Manager who was interviewed four times because he was able to contribute so much rich and complicated material that needed to be clarified over several interviews. The interviews lasted between one to four hours.

In this interview round, emphasis shifted to narratives. This was because during the first and second interview rounds, the interviewees had already recounted some narratives spontaneously in order to illustrate their points. These narratives appeared so interesting that in the third interview round more and richer narratives were explicitly invited. Specifically, the interviewees were invited to present narratives of events that they judged to have been significant in terms of information acquisition and innovation outcomes. Continuing with the focus on concrete work tasks by the individuals interviewed, narratives that were invited were narratives of personal experience, defined as "report(s) of sequence(s) of events that have entered into the biography of the speaker by a sequence of clauses that correspond to the order of the original events" (Labov, 1997: 397). In such narratives, a teller takes a listener into a past time or "world" and recapitulates what happened then to make a point. Personal narratives may be considered, especially in a context such as that under study here, to be particularly valuable because such narratives involve a personal theory of causality (Labov, 1997: 402). This is because a personal narrative is a report of a sequence of events, involving the narrator assigning "blame and praise to the actors for the actions involved" (Labov, 1997: 403). It can thus be considered the narrator's personal theory of what happened and why, involving an evaluation of the events that compares them with events in an alternative reality that was not in fact realized.

Gathering these kinds of narratives was seen to be particularly productive in these interviews because it appeared that it was largely the way the management team members organized their experiences and drew more general conclusions from them. Moreover, since the focus in the study was information activities, which involve high levels of personal subjectivity, it was deemed particularly fruitful to gain understanding of events that could include such subjectivity. Therefore, in contacting the six management team members by e-mail for this round of interviews, they were asked to think about events in

which information acquisition had been particularly important in leading to innovation outcomes. Moreover, they were asked to recount at least one event in which they considered the innovation outcome to have been successful and at least one in which they considered the innovation outcome to have been less successful. To help prompt narratives, and especially their specifics, the idea of social networks and personal connections being important to information acquisition for innovation in modern biotechnology was adopted from existing literature, and specific questions were asked about the persons involved in each event. Therefore, the questions that were communicated to the interviews in an e-mail and re-iterated at the beginning of each interview were as follows:

1) Could you please describe an event(s) in which external information has been important and the outcome of work tasks (such as development of a new product version etc.) has been successful?
2) Could you describe 3-5 individuals who were important in this event?
3) What (what kinds of) information did they have that was important?
4) What kinds of work roles were they in?
5) What was their educational/professional background?
6) What country were they in?
7) How would you describe your relationships to these individuals (e.g. current or former colleague, employee at a customer company, individual met at an industry fair, etc.)?
8) Why were you in contact with these individuals?
9) Where did you know these individuals from?
10) How frequently were you in touch with these individuals?

However, it was also important to collect data on events in which the innovation outcome had not been successful in order to provide material for comparison. Therefore, interviewees were also asked to recount narratives in which the innovation outcome had been less successful. Hence, the same questions were asked, but of events in which the outcome had been less successful:

1) Could you please describe an event(s) in which external information has been important and the outcome of work tasks has been less successful?

2) Could you describe 3-5 individuals who were important in this event?
3) What (what kinds of) information did they have that was important?
4) What kinds of work roles were they in?
5) What was their educational/professional background?
6) What country were they in?
7) How would you describe your relationships to these individuals (e.g. current or former colleague, employee at a customer company, individual met at an industry fair, etc.)?
8) Why were you in contact with these individuals?
9) Where did you know these individuals from?
10) How frequently were you in touch with these individuals?

The interviewees were surprisingly willing to recount narratives of both successful and less successful outcomes and in many cases provided multiple narratives. There was some variation of how clearly they articulated their views concerning the reasons for success or lack of it, but altogether, the interviews provided several interesting narratives. Most interviewees provided more than the two minimum accounts asked for, thus providing abundant material. However, most of the narratives were so rich that they needed to be delved into further, thus necessitating second and third interviews in this round. Each of the management team members was interviewed three times during this round in order to delve deeper into interesting and unclear topics that had come up in the first interviews, as well as making sure that the interviewees had been able to express their thoughts and sentiments in the way they wished. The interviews in this round lasted between one to four hours.The additional interviews were also necessary in order to clarify and confirm many of the points of the narratives. Therefore, all interviews in this round focused on the narratives, but while the first interviews focused on the interviewees recounting narratives, the second and third interviews focused on delving deeper into the already recounted narratives.

Fourth Interview Round Themes and Questions

The fourth round of interviews took place with the Managing Director to round out the empirical research. This round included two extensive interviews with the Managing Director, focused on ascertaining the results derived from the

previous interview rounds and on deepening the understanding of the conclusions drawn from them. Changes in the world economy as well as developments at FinnBiotech had resulted in such a wealth of developments that several interviews with the Managing Director were again necessary in order to capture all of the relevant data.

This interview round did not introduce new themes but rather sought to enrich the collected material by gaining a longitudinal view to it. This was especially important because many of the events recounted in the earlier interviews were only fully coming to fruition later on, making it possible to judge their success only at this point. Consequently, conducting interviews with the Managing Director in 2011, four years after finishing the first three interview rounds, made it possible to take advantage of a longitudinal research design in real time in addition to collecting data on FinnBiotech's activities prior to the year 2005 when data collection at this research site was first started. This made it possible to see how the events on which data had been collected between the years 2005 and 2007 had played out in the longer term, adding a valuable dimension to the data.

Summary of Interviews

The four rounds of interviews resulted in a total of 40 interview with the six management team members. As mentioned before, all of these interviews were conducted face-to-face at FinnBiotech's Vantaa facilities by the author of this study. The interviewees as well as the author of the study are all Finnish and therefore the interviews were all conducted in Finnish. The four interview rounds followed the interview guidelines set out for each interview round and communicated to the interviewees prior to the interviews. All interviews were recorded with the permission of the interviewees and transcribed verbatim in Finnish. The transcripts were sent to the interviewees after the interviews by e-mail so that they could check them for correctness. Data collection was carried out until saturation in the grounded theory sense, which is that no new categories of data appeared to be arising in the data collection. The following table summarizes the interviews conducted, including the interviewees as identified by their work roles (rather than by name because of their wish for anonymity), topics of the interview, the place and format in which the interviews were conducted, the language in which the interviews were conducted, and the interviewer.

Table 1: The Four Interview Rounds of the Empirical Study

First Interview Round (2005)						
#	**Interviewee**	**Topic**	**Place**	**Format**	**Language**	**Interviewer**
1.	Managing Director	FinnBiotech's activities	FinnBiotech, Vantaa	Face-to-face	Finnish	Author
2.	Managing Director	FinnBiotech's activities	FinnBiotech, Vantaa	Face-to-face	Finnish	Author
3.	Managing Director	Managing Director's activities	FinnBiotech, Vantaa	Face-to-face	Finnish	Author
4.	Managing Director	Managing Director's activities	FinnBiotech, Vantaa	Face-to-face	Finnish	Author
Second Interview Round (2005)						
5.	R&D Manager	R&D Manager's activities	FinnBiotech, Vantaa	Face-to-face	Finnish	Author
6.	R&D Manager	R&D Manager's activities	FinnBiotech, Vantaa	Face-to-face	Finnish	Author
7.	R&D Manager	R&D Manager's activities	FinnBiotech, Vantaa	Face-to-face	Finnish	Author
8.	Export Manager	Export Manager's activities	FinnBiotech, Vantaa	Face-to-face	Finnish	Author
9.	Export Manager	Export Manager's activities	FinnBiotech, Vantaa	Face-to-face	Finnish	Author
10.	Export Manager	Export Manager's activities	FinnBiotech, Vantaa	Face-to-face	Finnish	Author
11.	Production Manager	Production Manager's activities	FinnBiotech, Vantaa	Face-to-face	Finnish	Author
12.	Production Manager	Production Manager's activities	FinnBiotech, Vantaa	Face-to-face	Finnish	Author
13.	Production Manager	Production Manager's activities	FinnBiotech, Vantaa	Face-to-face	Finnish	Author
14.	Quality Manager	Quality Manager's activities	FinnBiotech, Vantaa	Face-to-face	Finnish	Author
15.	Quality Manager	Quality Manager's activities	FinnBiotech, Vantaa	Face-to-face	Finnish	Author

16.	Quality Manager	Quality Manager's activities	FinnBiotech, Vantaa	Face-to-face	Finnish	Author
17.	Technical Manager	Technical Manager's activities	FinnBiotech, Vantaa	Face-to-face	Finnish	Author
18.	Technical Manager	Technical Manager's activities	FinnBiotech, Vantaa	Face-to-face	Finnish	Author
19.	Technical Manager	Technical Manager's activities	FinnBiotech, Vantaa	Face-to-face	Finnish	Author
Third Interview Round (2006)						
20.	Managing Director	Managing Director's narratives	FinnBiotech, Vantaa	Face-to-face	Finnish	Author
21.	Managing Director	Managing Director's narratives	FinnBiotech, Vantaa	Face-to-face	Finnish	Author
22.	Managing Director	Managing Director's narratives	FinnBiotech, Vantaa	Face-to-face	Finnish	Author
23.	R&D Manager	R&D Manager's narratives	FinnBiotech, Vantaa	Face-to-face	Finnish	Author
24.	R&D Manager	R&D Manager's narratives	FinnBiotech, Vantaa	Face-to-face	Finnish	Author
25.	R&D Manager	R&D Manager's narratives	FinnBiotech, Vantaa	Face-to-face	Finnish	Author
26.	R&D Manager	R&D Manager's narratives	FinnBiotech, Vantaa	Face-to-face	Finnish	Author
27.	Export Manager	Export Manager's narratives	FinnBiotech, Vantaa	Face-to-face	Finnish	Author
28.	Export Manager	Export Manager's narratives	FinnBiotech, Vantaa	Face-to-face	Finnish	Author
29.	Export Manager	Export Manager's narratives	FinnBiotech, Vantaa	Face-to-face	Finnish	Author
30.	Production Manager	Production Manager's narratives	FinnBiotech, Vantaa	Face-to-face	Finnish	Author
31.	Production Manager	Production Manager's narratives	FinnBiotech, Vantaa	Face-to-face	Finnish	Author

32.	Production Manager	Production Manager's narratives	FinnBiotech, Vantaa	Face-to-face	Finnish	Author
33.	Quality Manager	Quality Manager's narratives	FinnBiotech, Vantaa	Face-to-face	Finnish	Author
34.	Quality Manager	Quality Manager's narratives	FinnBiotech, Vantaa	Face-to-face	Finnish	Author
35.	Quality Manager	Quality Manager's narratives	FinnBiotech, Vantaa	Face-to-face	Finnish	Author
36.	Technical Manager	Technical Manager's narratives	FinnBiotech, Vantaa	Face-to-face	Finnish	Author
37.	Technical Manager	Technical Manager's narratives	FinnBiotech, Vantaa	Face-to-face	Finnish	Author
38.	Technical Manager	Technical Manager's narratives	FinnBiotech, Vantaa	Face-to-face	Finnish	Author
Fourth Interview Round (2011)						
39.	Managing Director	Update on FinnBiotech's activities	FinnBiotech, Vantaa	Face-to-face	Finnish	Author
40.	Managing Director	Update on FinnBiotech's activities	FinnBiotech, Vantaa	Face-to-face	Finnish	Author

3.3 DATA ANALYSIS

3.3.1 Coding and Categorizing

The first step in data analysis was to prepare two further documents from the interview transcriptions to function as the basis for further analysis. The first of these documents was a version of each interview transcription coded according to conceptualization of data, since it is from conceptualization of data, not the actual data *per se*, that conclusions are drawn (Strauss & Corbin, 1998). This analysis was started with the completion of the very first interviews and their transcriptions in order to capitalize on the grounded theory approach of constantly comparing and contrasting data throughout the data collection and analysis process. Therefore, as the interviews were being

completed, each interview was subjected to a process of coding using developing concepts and categories.

Concepts are the basic units of analysis in Straussian grounded theory. The first round of codes that gradually emerged as fitting the transcripts involved the subject areas of information used for innovation. It began emerging from the very first interviews that information acquisition activities related to different subject areas differed quite substantially from each other so that it was impossible to speak of information acquisition activities in general. Therefore, the first set of codes applied to the transcripts was as follows: (1) information about science; (2) information about products and product development; (3) information about production and production technology; (4) information about customers and markets; and (5) information about quality, regulation, and patenting. When presented with this coding scheme in the subsequent interviews, the interviewees confirmed that this made sense and further provided evidence of the ways in which the different domains differed in their dynamics. Therefore, the data was arranged according to these codes. In addition, two other codes emerged that touched upon all of the information domains. These were the importance of "right information" and the facilitating factors in information acquisition in the international marketplace.

Having arranged the data according to the coding scheme explicated above, the next step was to move to the second level of abstraction in grounded theory analysis, that of categories. Here the grounded theory coding paradigm developed by Strauss and Corbin (1998) proved to be a valuable heuristic aid. Hence, the data organized according to the codes of information domains was subjected to a review using this heuristic aid, which covers the following: (1) conditions/context; (2) strategies and tactics in action; (3) strategies and tactics in interaction; and (4) consequences. These items were modified to better fit the specific data, giving rise to the following items to be used in categorizing data: (1) sources of acquiring information; (2) ways of acquiring information; (3) ease of acquiring information; and (4) difficulties and challenges experienced in the acquisition of information. By combining these items with the previously coded data, it was possible to derive descriptions of information processes leading to innovation that captured both the specifics of different information domains and the dynamics of each information domain.

3.3.2 Narrative Analysis

The narratives told in the interviews by the interviewees were separated from the verbatim interview transcriptions and re-transcribed using Labov's (Labov, 1972, 1981, 1997, 2001; Labov & Waletzky, [1967] 1997) event structure of narratives. This involves identifying the core narrative and reducing it to a skeleton plot using structural categories so that parts of the narrative are identified by their function. These parts are (Labov, 1972: 363): `

1) Abstract: an initial clause in a narrative that reports the entire sequence of events of the narrative
2) Orientation: gives information on the time, place of the events of a narrative, the identities of the participants and their initial behavior
3) Complicating action: the clause of complication action that is a sequential clause that reports a next event in response to a potential question, "and what happened (then)?"
4) Evaluation: provides evaluation of a narrative event; evaluation of a narrative event is information on the consequences of the event for human needs and desires
5) Resolution: the set of complicating actions that follow the most reportable event
6) Coda: a final clause which returns the narrative to the time of speaking, precluding a potential question "and what happened (then)?"

As this chain of causal events as described by an interviewee is intimately linked with the assignment of praise and blame for the actions reported, it allows insights into the interviewee's perception of the events in terms of his/her individual theory of what happened and why. It thus makes it possible to analyze the personal narrative as a subjective theory of the causes of the "most reportable event" (Labov, 1981, 1997). In this particular study, it made it possible to examine the events told by the interviewees that had significantly involved external information acquisition and had led to successful and less successful innovation outcomes, both from a factual point of view and taking into account the interviewees' own perceptions of why the events had unfolded as they did. This was important because activities involving information are highly reflexive, and the participants' own perceptions of events and the reasons for their unfolding to result in either successful or less successful innovation outcomes formed an important portion of the data.

4 RESULTS

This chapter presents the results of the empirical study conducted at FinnBiotech. Throughout this chapter, the conventional distinction between "knowledge" and "information" is retained as presented in the introductory chapter: knowledge is acquired information, information that has been found, selected and gathered, often from many sources, assembled into packages and available for use. However, it is important to point out a translational detail: the results presented in this chapter derive from interviews conducted in Finnish. In the Finnish language, there is only one term for both "knowledge" and "information," which is "*tieto*." Hence, the Finnish language did not allow for a linguistic distinction between the two concepts in the interviews. As a result, the term "information" is used predominantly throughout this chapter as a translation of the Finnish word "*tieto"* used in the interviews.

The results are organized following the data analysis methods described in the preceding chapter. Therefore, the first part of this chapter is organized according to the descriptions of these information domains and their dynamics. In addition, important issues that came up spontaneously in the interviews about the importance of "right information" and of ability to use it, as well as of facilitating factors in information acquisition in the international marketplace are explicated. The second part of this chapter presents the narratives gathered in the interviews, presented according to the Labovian event structure and grouped into narratives of successful innovation outcomes and into narratives of less successful innovation outcomes. Not all of the narratives gathered in the interviews are presented here, but only those that were told in greatest richness and which appeared to have been especially significant for FinnBiotech, evidenced by the fact that some of them were told by more than one person. Where this happened, the write-up represents a merger of the accounts.

The terms "FinnBiotech" and "management team" or the job titles of specific members of the management team are used quite synonymously in this description. This is because information acquisition processes are handled as taking place at the individual level. When specific individuals predominantly handle certain types of information, they are referred to by their job titles. When the information acquisition activities involve all of the management team members, the term "management team" is used. Finally, when the entire operations of FinnBiotech are referred to (for instance, when

talking about competitiveness or profitability, which are organization-level issues), or the information acquisition activities affecting such operations, the term "FinnBiotech" is used. However, the information acquisition activities are always at the level of individuals, and no specific attention is paid to how such individual-level information is transformed into organizational knowledge because FinnBiotech is small enough as an organization that the management team members all share information with each other without problems, especially as they are located at the same physical facility. Several of the management team members stressed that they shared information very openly and actively with each other, and with the rest of the company employees.

As the Production Manager, a 25-year veteran of FinnBiotech, described it:

> *"Everyone is together in the same facility—product development, quality control, production, everything. Everyone is working together, so communication of information is really good. Nobody sits in his or her room, but everyone works together, so that it is easy to share information constantly. Even though the facility has two floors, people run between the rooms all the time during the day, because even though everyone carries a mobile phone, communication is best face-to-face."*

The R&D Manager, a 17-year FinnBiotech veteran, expressed similar sentiments, noting:

> *"Because the company is so small, sometimes I have to jump in to help with any task if somebody is away or if there is a time crunch, which means that I have good knowledge of all the developments in the company."*

The Export Manager, a 25-year FinnBiotech veteran, stressed the role of the Managing Director in encouraging this egalitarian company culture in which everyone, regardless of position, helps out with any task, which has led to a strong sense of camaraderie that supports open information sharing:

> *"When things get busy, the Managing Director himself jumps in to help in production or packaging or whatever needs*

doing. So it feels easy to communicate with him after I have been standing next to him on the production line packaging products."

The Production Manager also emphasized the close interaction of the management team with the rest of the company employees:

"It is important for the management team to stay very close to the ground and to be familiar with all aspects of the company's activities. This comes through interaction and communication with everybody."

Although none of the interviewees specifically mentioned it, it is also likely that the fact that all of the management team members have been with the company for so long also facilitates open internal communication. Such long tenures could also lead to silos and to keeping information from each other because of internal politics that could have developed over the years, but this truly did not appear to be the case. It seemed from the interviews, as well as from observation of behavior at the company facility, that the company culture really was egalitarian and informal, characterized by high levels of trust among all of the employees and easy, open interactions. The role of the Managing Director appeared to have been central in this, as the other management team members had several positive anecdotes to tell about him and the way in which he was willing to participate in even the most menial task at the company, thus making the employees feel valued and that they could trust him. Of course, a few management team members did mention slight problems at times in communication resulting from everyone being so busy that they sometimes forgot to share a piece of information with the others. However, the way these problems were described made them appear as rare, isolated instances related to small, rather inconsequential pieces of information. Moreover, in nearly every instance described, the information was communicated a bit later when it became apparent that the person holding that information had forgotten to pass it on to relevant employees.

4.1 INFORMATION DOMAINS AND DYNAMICS

4.1.1 Importance of "Right Information"

Prior to describing the identified information domains and their dynamics, it is essential to present an important theme that emerged in all of the interviews and which runs through all of the information domains: the importance of "right information." All of the interviewees emphasized that acquiring information *per se* is not difficult, but acquiring the "right information" is. Especially in the current world of digitalized information, there is rarely ever a shortage of information. Rather, challenges have shifted to not just acquiring information, but to acquiring the "right information" for the issue at hand. Indeed, the current onslaught of information may even make this task of acquiring the "right information" more difficult, as the interviewees all described having challenges shifting through all of the voluminous information available to find the wheat from the chaff (or to determine that there was no wheat at all to be found in a particular pile of chaff). The Managing Director put it aptly already early on in the interviews, but the same theme was echoed throughout the interviews with the other management team members:

> *"There is so much information nowadays and much of it is unnecessary. There is certainly no lack of information. However, there may be lack of right information. Important information is only a small part of all information that is available."*

All of the interviewees described the concept of "right information" in much the same terms, as being focused, relevant, reliable, and correct information. As the Managing Director described it:

> *"The difficulty with information is to be able to tell good information from bad. Reliability makes information valuable, and reliability of information comes from being able to confirm the information from several sources and from being able to see how the information has been produced. If information comes from only one source, it cannot be relied upon. Incorrect information is dangerous*

because it can lead to mistakes. For a small firm like us, making wrong choices and going down wrong paths because of incorrect information can be fatal."

Moreover, all of the interviewees described getting from the surplus of available information to "right information" as requiring activity. This involved actively seeking out necessary information, shifting through all the information available to find that which was needed, and then evaluating it for reliability, analyzing it, and combining it with other information to draw conclusions. Furthermore, although the interviewees did not explicit state so, it was possible to identify that this activity also required expertise. As the Managing Director put it:

"What is of primary importance is being able to select what is good and worthwhile information. … One needs to be able to detect what is relevant and valuable, select amongst information, and determine what is reliable. … Even then, information in itself is not valuable. One must gather various pieces, assess and evaluate them for reliability and relevance, combine and interpret them, and then one can figure things out and see the bigger picture."

Moreover, information—even if it is "right information" and is processed into knowledge—is not valuable if it cannot be used. As FinnBiotech's Managing Director put it:

"Information in itself is not valuable; it needs to used. This presents the challenge of turning spirit into flesh, so to say."

4.1.2 Information about Science

Knowledge about science is the foundation and starting point for FinnBiotech's operations. The company came into being on the basis of developments in science: the 1980s were a time of revolution in immunodiagnostics, and research carried out on the new techniques in Finland provided the starting point for FinnBiotech. Moreover, the 1980s revolutionary changes in immunodiagnostics depended on decades of scientific work. These include the 1950s development of the radio-

immunoassay and the 1960s replacement of radioisotopes by enzymes, the development of the hybridoma technique in the 1970s, and the advent of automated plate reader systems and personal computers to analyze data in the 1980s. As these several developmental trends converged, it became possible to develop entirely new kinds of tests, such as the rapid immunochromatographic tests that formed the starting point for FinnBiotech. Hence, science is a *sine qua non* for FinnBiotech, since the firm would not exist without the multiple developments in science over several decades. The first-hand experience in these developments by the founders of FinnBiotech made it possible for them to have the knowledge about these latest developments in science, which in turn made it possible for them to see the business opportunity in this field and seize it. The founders' own scientific background also provided the basis for generating revenues in the beginning in order to cover high R&D costs, as they were able to prepare and sell more basic agglutination tests while developing immunochromatographic tests, the production of which they started in 1990, four years after FinnBiotech's founding.

Beyond having had its start in science, FinnBiotech must continuously be able to handle information about science in order to develop new products, keep existing products up-to-date, and to be able to manufacture the products it develops. The scientific field of immunodiagnostics changes quite rapidly, and academic scientists as well as for-profit and non-profit organizations are constantly developing new assays with higher sensitivities which will enable the discovery of new biomarkers. As a result, products already on the market quickly become outdated as they are no longer at the cutting edge of scientific development. Consequently, the competitiveness and profitability of such products are significantly negatively affected. Therefore, if FinnBiotech is to uphold the competitiveness and profitability of its existing products, it must be aware of the latest developments in science. This is the only way it can ensure that its products are up-to-date and therefore competitive vis-à-vis the offerings of competitors. FinnBiotech must also continuously innovate in terms of being able to develop new products in order to maintain competitiveness and profitability. This is because even when existing tests are as up-to-date as possible, the more mature they are, the lower their prices. Therefore, fresh, innovative products are the pre-eminent profit-generators for FinnBiotech. To produce these, it is crucial to keep up with developments in the field of science, which can provide new ideas and at best, unique inventions for FinnBiotech to commercialize.

The main individuals at FinnBiotech who deal with R&D are the Managing Director and the R&D Manager. They use multiple sources for

acquiring scientific information. The basic and most straightforward way of acquiring scientific information is through scientific publications. Both the Managing Director and the R&D Manager experience this as easy and quite routine. As the Managing Director put it:

> *"Scientific information is public and much of it is available digitally via the Internet. There are both free publications and ones you have to pay for, but as a docent at the University of Helsinki, I have access to them all. I just look them through to see what is relevant and rank articles according to which ones have information relevant to us, both to tests that we are already making and to tests that we might make. The databases are huge and public, as nearly all scientific publication is public. There is a plethora of scientific information available, and simply having access to it is not a problem. However, searching, selecting, evaluating, and analyzing among the deluge of available information may be a challenge."*

The R&D Manager echoed this sentiment, stating:

> *"If it is necessary to search for scientific information, it is quite routine work … it is always possible to find information … there is a lot of scientific information, and getting it depends on activity and ability to find and choose. If there is some specific information that needs to be looked up, I usually delegate that task to someone else."*

Scientific conferences are another way of acquiring scientific information. FinnBiotech's management team members—again, mostly the Managing Director and the R&D Manager—actively attend multiple scientific conferences around the world, where they can acquire information about latest developments in science that have not yet been published. They also use conferences as a way to meet interesting researchers and to gain ideas for new tests. For instance, the Managing Director attended a scientific conference in Japan in the early 2000s and listened to a presentation about a new technology that he thought could be used to develop a new test for FinnBiotech's product portfolio. Hence, scientific conferences provide a way to

stay up-to-date on the latest developments in science even before they make their way into publications and suggest ideas for updating tests and developing new kinds of tests. Moreover, they provide a venue to make new connections with scientists and to meet scientists with whom the Managing Director and the R&D Manager are already familiar.

FinnBiotech has a plethora of connections with university scientists, most of them informal and most of them friends of the Managing Director. The R&D Manager is also well on his way to developing his own networks, but because of his younger age has simply not had the chance to develop the same width of network that the Managing Director has. These informal connections with scientists are used to acquire information about new research projects that have just started or are starting, thus providing information of scientific developments already in the embryonic stage before even conference presentations could be made of them. This makes it possible to sense where the field is likely to be developing in the future. Some of the informal ties also develop into formal collaborative projects, as in the case of working to develop the world's first cancer diagnostic test for commercial use together with scientists at the National Institutes of Health in the United States, in South Korea, and in Russia. Similar collaborative projects, albeit on a smaller scale, have been realized in collaboration with scientists in Italy with the aim of jointly developing a new test. However, none of these collaborations has yet resulted in new products.

In addition to networking and collaborating with scientists around the world on its own initiative, FinnBiotech has also taken part in several projects orchestrated by Finnish public authorities and European Union authorities. These projects have also largely grown out of personal connections, as friends (especially of the R&D Manager) are active in alerting FinnBiotech to interesting projects and recruiting the company to become involved in these projects. A major motive in this collaboration is the fact that the public authorities that fund R&D projects in Finland, such as *Tekes*, require that the projects include public-private collaboration between universities and companies. The same applies to European Union-funded R&D projects. However, these projects are mostly for keeping up connections with universities and ensuring access to what is going on in them. As the R&D Manager said:

> *"FinnBiotech's role in these projects is mostly in participating on the board of directors without any financial investment in the projects. So we don't really even expect that we would get*

something concrete from the projects in the near future, but really just participate in order to maintain relationships to scientists and universities and to keep up with what is going on in universities."

Thus, these projects have not led to lasting collaborations with universities, and while FinnBiotech has a wide network of connections in universities around the world, they are very much connected to the person of the Managing Director. This is one instance in which information sharing within the company appeared to not always be optimal, because sometimes the information acquired from these contacts could stop at the Managing Director, who did not always have time to share the information or did not remember to do so. Therefore, the firm has sometimes been caught in a situation in which they have had a test in the market which has been outdated from a scientific point-of-view because the latest scientific results have escaped the management team's attention.

All in all, scientific knowledge is crucial for innovation at FinnBiotech and the management team members—especially the Managing Director and the R&D Manager—continuously and actively acquire information about science from multiple sources. However, scientific knowledge only forms a general background to the company operations. It is a *sine qua non*, a necessary but insufficient information domain which needs much complementary information in order to generate innovations from it. The R&D Manager summarized it well:

"Research at universities is not very applied … it is the kind of research knowledge that is difficult to use for our operations, because it cannot help us in our short-term projects. Maybe if we did a long-term project, then we could better use university research. But we cannot really do that, because as we are a small company, our strategy is to focus on short-term projects where we can get a payback in a short amount of time. Trying to develop a radical innovation is extremely difficult, nearly impossible for a small company, because it requires a long time of great investments with an elusive payback only in a very distant future, so it is unrealistic and excessively risky for us."

There has been only one event where FinnBiotech has directly been able to use university research in its innovation. However, the distinguishing feature of this event is that the scientist at the University of Tampere in Finland had proceeded so far in development that he had a ready invention, an entirely new test for celiac disease that was one of a kind in the world. Moreover, the university's technology transfer office had already taken care of patenting the invention, and offered the licensing rights to the invention to prospective applicants. FinnBiotech was extremely keen to purchase the licensing rights, succeeded in doing so, and went on to commercialize this invention to great success.[40]

Co-location, which has been paid great attention to in the modern biotechnology sector, appeared to play only a limited role in FinnBiotech's information acquisition about science. Certainly, co-location was determinative in the founding of the company, as FinnBiotech was established in the Helsinki metropolitan area where the science it was founded on was developed. However, since its founding, it is clear that it has not been able to rely on the convenience of local contacts. Local contacts are advantageous, as the management team members have close contacts to universities in Finland, underpinned by the Managing Director's docent position at the University of Helsinki. However, it became clear in the interviews that in seeking to acquire the best and latest scientific information, FinnBiotech's management team members had to endure lots of air travel all around the world, as they needed to go where the needed information was. This also meant relying heavily on digital communications, even if face-to-face communications would have been preferable. Surprisingly, however, it did not come up either directly or indirectly in any of the interviews that networking internationally rather than locally would have presented particular difficulties (beyond the need for expensive and time-consuming air travel), although establishing some of the international scientist connections involved peculiar events that will be described in the narratives section.

A surprising finding, which is rarely acknowledged when discussing the acquisition of scientific information in modern biotechnology, was that universities were certainly not the only sources of such information, and possibly not even the most important. Instead, it turned out that the primary purveyors of scientific information to FinnBiotech were FinnBiotech's suppliers. The immunochromatographic tests developed and produced by FinnBiotech are made up of hundreds of ingredients, all of which are being constantly developed, as reagents and raw materials are critical for the quality

[40] This event will be elaborated on in the section of event narratives.

and cost of the tests. The suppliers of these ingredients are highly specialized in their own areas and up-to-date about scientific developments in their specialties. As FinnBiotech is a customer for these suppliers, it is in the suppliers' interests to interact frequently with FinnBiotech, making visits to Finland to present their latest products and, at the same time, provide information about the latest scientific developments in their area. The suppliers openly share this information as it is in their interests: it is part of their marketing efforts to explain how and why their latest products are at the cutting edge of science and how they differ from competing products. The suppliers are thus active, open, and forthcoming about sharing this information. Moreover, as this scientific information is highly specific to FinnBiotech's innovation processes, it is very relevant to FinnBiotech.

All the management team members hold graduate degrees in areas related to life sciences, most of them from the University of Helsinki, which is highly ranked internationally overall and very highly ranked in the life sciences. After their graduate studies, the management team members all have gained several years of experience in their field, ranging from the low of 13 years to a high of 43 (this last being the Managing Director, who had significant expertise in responsible positions prior to founding FinnBiotech). Therefore, they could all be considered to have very high expertise in the field. They found the acquisition of scientific information to be easy because of this expertise. For individuals who had attempted to acquire the same scientific information without the expertise, the process and the results would most likely have been very different. What this underscores is the importance of expertise in information acquisition, a point which may seem obvious but is not always paid much attention.

4.1.3 Information about Products and Product Development

Science forms the basis for product development. However, it is not enough, as noted before. This process was described by the Managing Director in terms of one company product:

> *"For example, how celiac disease can be diagnosed is the culmination of a long, gradual process of scientific research. Now it has been noticed how technology can be used to better diagnose celiac disease, and this combination has been turned into a product innovation. Thus, one must keep track of lengthy records of scientific evidence, but one must be able to*

combine these with technology to allow masses of tests to be manufactured at consistent quality and low cost."

FinnBiotech must therefore be able to keep up with information about science incessantly, but also be able to turn information about science into products that consistently function at required quality levels and can be mass manufactured at consistent quality and decent cost. Moreover, to maintain competitiveness, FinnBiotech must continuously keep existing products up-to-date and develop new products. The field is highly competitive and changes quickly, so that products in the market face quick price depreciation. Thus, to maintain profit margins, FinnBiotech must constantly be putting out new generations of products as well as entirely new products. This creates tensions for the firm, as the manufacturing costs of new products are higher because of lower production volumes and lack of production experience, but to maintain profitability as well as innovative image, new products are essential. FinnBiotech is thus in a constant product development race.

The immunochromatographic tests that FinnBiotech develops and manufactures are composed of roughly seven to nine components and hundreds of ingredients.[41] Performance attributes and manufacturing considerations can vary dramatically from one diagnostic test to another. To be competitive, a test needs to be technically optimized to have the highest possible sensitivity and specificity, while being amenable to being mass-manufactured at low cost. Additionally, a good test is about more than just science and technology, having been designed with user needs in mind, so that the test is ergonomic, intuitive, and has graphic instructions. However, as FinnBiotech competes on quality and price, it emphasizes these attributes in its product development.

This can be understood better when one considers the structure of the rapid test market. The market is polarized into a few big players, such as Abbott Laboratories, and hundreds of smaller players vying for market space. Although well-known and respected, FinnBiotech is still one of these small

[41] The common components of these products are a sample pad, a conjugate pad, detection conjugate, solid phase membrane, test and control reagent lines, absorbent pad, and plastic-adhesive backing card. The components are layered onto the plastic backing card, and each component must be carefully positioned so that they overlap. The assembled strips are dried and packaged, making them stable for months when properly protected from moisture and excessive heat. Packaging of the strips is typically done with laminate cover tape which acts as a protective barrier and prevents evaporation of reagents and helps to limit back-flow of reagents, and a strip housing/cassette which protects the assembly, containing the test strip and the absorbent pad so that the unit can be handheld more easily.

players. Because of its small size and limited resources, it has adopted a strategy of incremental innovation where it follows what the large players are doing and then brings out an innovative alternative solution of high quality and decent cost. For instance, if a large company has developed and launched an entirely new type of test, FinnBiotech will look to offering a similar kind of test in a rapid test format. This strategy is followed because to create markets for radical innovations requires changing behaviors and entire healthcare system structures. The resources to bring about such changes and to create new markets and demand are held only by big companies. Therefore, FinnBiotech starts its product development work from existing demand, and focuses its efforts on creating high-quality, moderate-cost tests to meet that existing demand.

Product development knowledge has been predominantly developed and kept in-house because of the Managing Director's management philosophy. The reason for this has been largely the fact that there is so much unique knowledge and experience that resides within FinnBiotech, that it is not necessary to collaborate very widely when it comes to product development. Thus, in line with company strategy, products are nearly all developed in-house at FinnBiotech, mostly through experience. As the R&D Manager described it:

> *"Knowledge for developing products and keeping them up-to-date is not the kind of knowledge where one could say that when you do one thing, it leads to another. … What I mostly use in my work is knowledge that has been gained through experience. When you have experience, and insight that has been developed on the basis of experience, it's possible to guess how things will work. Most of the work time goes to overseeing what is being done, making decisions as to which direction we should go. It's the kind of work where you cannot have certain knowledge that doing X will solve the problem. It's more like guesswork informed by having seen a similar situation so many times that you know what to try."*

However, despite wanting to keep the core of product development, and the knowledge and expertise related to it, in-house, FinnBiotech is keenly alert to information related to products coming from multiple sources. The two main sources of information related to product development are industry fairs and customers. Industry fairs are opportunities to keep up-to-date with

what other relevant market actors are doing, especially competitors, so as to know where the leading edge is. As both the Managing Director and the R&D Manager described it, in industry fairs, competitors display their latest products, so that attending the most important industry fairs around the world and actively walking around, inspecting things, and talking to people makes it possible to keep on top of what products are being brought out by competitors. This provides ideas on how to keep the company's existing products competitive, and on developing new products. As the Managing Director put it:

> *"One hears things from people in the industry sector … ideas come from industry fairs where one meets people, sees what is available, hears of things."*

Indeed, being able to survey competitor offerings is a central activity in at least two industry fairs, one in North America and one in Europe. The industry fair in North America showcases perhaps the most cutting-edge advances from competitors, making it easy to find new product ideas. The industry fair in Europe is possibly not quite so cutting-edge, but as Europe is one of FinnBiotech's key market areas, it is extremely important to see what competitors are offering. This industry fair offers fewer new product ideas, but makes it possible to gauge the situation in European markets. Therefore, for example, if it is seen that a rapid test for a certain condition is not available, FinnBiotech will know to speed up its development process in order to be among the early entrants in the market. Certainly, especially in cases where ideas for brand new products are to be found only in the industry fairs, rather than in products already in development, it is unlikely that FinnBiotech will be the first to market with a certain test. As the R&D Manager explained:

> *"Development of a new product typically takes two to three years. In that time, it is likely that competition will emerge. However, this is not necessarily bad. For instance, if a large company enters the market with a similar test before we do, that can even be good for us, because they can create a market for that test. It is difficult to be first to market, so if we can follow in their footsteps, providing an innovative and possibly cheaper alternative, this is good for us."*

In addition to industry fairs, FinnBiotech has four sources of information alerting it to existing demand to which they could respond by developing a new generation of an existing test or a new test. As the R&D Manager explained:

> *"One, we notice that there is a problem in an existing product, and begin to develop that product further. If we are not talking about a crisis situation, then this is not a very hurried process, it is just that we are aware of a competitor having a better test and noticing that we should develop our test to the same level. But the process is largely contingent upon whether we can find new materials and how much development time we can invest. Second, we receive information from a customer that a certain test should be developed in a certain direction, or a customer wants us to develop a specific test. Third, we find an interesting topic and begin exploring whether we could develop a new test based on this. These ideas usually come from industry fairs or from meeting people, sometimes friends in the industry or material suppliers who have a new product. Sometimes, although rarely, ideas come from reading scientific publications. Our firm has a reputation that we are technologically oriented and have a low threshold to begin experimenting, so we also receive a lot of ideas and suggestions that we try out to see if they lead to anything. Four, we get a request to develop a custom-made test for a customer, for instance to develop a rapid test version of a test that the customer already has in another format. In such a case, we put a price tag on the R&D work that we do for the customer."*

Therefore, customers are an important source of ideas and information for product development. Customer communications are of special significance as it is in the interests of the customers to constantly monitor the wide range of products available and in development. The customers provide this information to FinnBiotech as they have an interest to have FinnBiotech, as their supplier, provide the best possible product range to them. Ideas coming especially from existing customers are in central position for product development, because it is in FinnBiotech's interests to keep their existing

customers happy in order to retain them. The Export Manager related a representative development of a new product based on customer feedback:

> *"The helicobacterium test was launched to market in 1995, and the entire product idea largely came from the fact that there was a laboratory test in the market but no home test. Our customer thought that there was clear market potential for a home test and wanted to have such a test in their product portfolio. So this is where the product development started. The product was the 'baby' of the Marketing Director at the time*[42] *and he was deeply involved in its development in the mid-1990s. The product development was successful, so although the idea for the test came from our customer, we did the product development work ourselves, and it turned out to be a success."*

However, keeping up interactions with customers around the world in addition to attending multiple industry fairs requires a lot of air travel. Indeed, the management team members fly around the world quite incessantly, especially the Managing Director, who was praised by all of his management team members as "*being good at sniffing out opportunities for new product innovations*." Altogether, looking at FinnBiotech's development over time, it is quite clear that there is a virtuous circle of first having some information, then gaining customers on the basis of that information, then gaining more information from the customers, then gaining more customers, then gaining more information, etc. FinnBiotech has thus been able to start and maintain a virtuous cycle where customers provide them with information to provide new products, which in turn help gain new customers, who in turn provide FinnBiotech with more information, in iterative cycles.

However, as with information about science, more is not always better. With information related to product development, there is also the challenge of identifying, evaluating, and interpreting the information that comes at industry fairs and from customers. It is critical to be able to evaluate what of this information is relevant, and, in the case of market rumors, to evaluate whether there is truth in them. In addition, customers present a plethora of requests for product improvements and new product developments, only some of which can and should be responded to, and it is crucial to know the

[42] One of FinnBiotech's founders, who sadly passed away before the beginning of this study.

difference. For example, although customers present very valuable new product ideas, they also present requests for FinnBiotech to develop products, which it must turn down. The Export Manager explained:

> *"We received a product request from a customer to develop a rapid drug test. However, when we looked at the situation, we realized that competitors had already had such tests in the market for a long time. For a small firm, it does not make sense to enter a mature market. If the market is already mature, then we are too late, because the prices will be low. Therefore, because we could tell that the market was mature and highly competitive, we told the customer that it was not worthwhile to begin developing the product they asked for. Only in a situation where we can develop a new generation of tests that have clear benefits over the older generations, might we enter a market. However, no such situation has come up, so we seek to enter markets that are not yet mature and do not have excessive competition."*

4.1.4 Information about Production and Production Technology

FinnBiotech has chosen a rather rare strategy among dedicated biotechnology firms in that it produces its own tests, instead of licensing its products or outsourcing production. This has been largely a matter of necessity, because much of the production equipment that FinnBiotech has needed in order to produce its tests has simply not been available. As the Technical Manager simply stated:

> *"There are not many manufacturers of equipment for (this) industry, so the types of equipment and machinery often simply are not manufactured."*

Therefore, FinnBiotech has had to develop much of its own production technology. Even when it buys ready-made machinery, it usually must significantly customize it to fit the needs of its own specialized production. Such customization has been possible because the expertise for production exists in-house and the critical phases in production are well known. This accumulated in-house experience provides knowledge about what have been

correct decisions and what decisions have caused problems that have needed to be solved. Therefore, the knowledge about production technology has been developed in-house through experience over many years, so that currently FinnBiotech has the best expertise in both building and customizing equipment for the production of its own tests. As the Technical Manager explained:

> *"Tailored equipment is developed and constructed in-house as this is where the best knowledge of the specific needs and critical production phases is … Technical development has gone on for many years and is based on accumulated knowledge from experience."*

Equipment that is purchased from the outside for customization in-house is procured routinely from existing partners who have sold equipment to FinnBiotech before and are knowledgeable about the company's needs. New links to equipment providers are also sought through industry contacts and industry fairs. Although price is a large decision factor, FinnBiotech prefers buying equipment from its old partners as it can rely on them. However, no equipment has been acquired that could have been used for production without in-house customization. Therefore, the knowledge and expertise concerning the construction and customization of production equipment for FinnBiotech is solidly in-house. Central in the development of expertise has been a single individual, who has been doing this kind machinery work for FinnBiotech for about 26 years, thus accumulating a wealth of knowledge and experience, familiarity with the biological materials and how to handle them. As a result, production technology is the one area in which knowledge is most tightly kept in-house. As the Technical Manager put it:

> *"In some cases it might be possible to cooperate with an equipment manufacturer, but it would be very unlikely because FinnBiotech does not want to reveal its latest developments to an outside firm, since a lot of very detailed information would need to be communicated in such case."*

Indeed, such protection of production knowledge makes sense, as FinnBiotech also earns revenues from licensing and selling its production technology, although this is not their core business. Thus, as knowledge

related to production technology has been developed in-house over a considerable period of time, this knowledge is mostly not shared with outside parties unless in the form of licensing or sales of machinery. Nor does FinnBiotech significantly acquire information about production technology from outside its own boundaries, as even equipment which is purchased is heavily customized in-house to fit FinnBiotech's production.

When a test has been developed in R&D, it passes on to production. Although in-house production, especially with technology developed in-house, is rare in a small dedicated biotechnology firm, it may be detected from the interviews that FinnBiotech has made a virtue out of necessity. None of the interviewees noted this outright, simply stating that it had been necessary to develop the company's own production technology because of lack of such technology in the markets. However, especially when the Production Manager described the process of adapting newly developed products to mass production, it appeared that having production co-located with product development at the Vantaa facility may have improved both product development and the adaptation of products to production. This was because both activities were in the same facility and it was easy to go back-and-forth in iterative cycles to fix problems that new products presented to mass production. This, in turn, was crucial because a test design that works well in the R&D lab is of little use if it is difficult to manufacture reliably—and at acceptable cost—at high yield. Indeed, manufacturing has a significant effect on the quality and cost of the tests produced. Thus, co-location made it possible to try the process of manufacturing tests under development, tweaking ingredients and design choices to optimize the test for production. Indeed, R&D and production carry out the first production batches of a new test jointly and work out possible problems at this point, so that mass production can then begin without problems.

4.1.5 Information about Customers and Markets

FinnBiotech's products are marketed and distributed by specialized diagnostic and pharmaceutical companies in more than 50 countries. The largest customers are in Europe and Asia, but over its history, FinnBiotech has sold its products to all parts of the world: Africa, Asia, Australia, Europe, the Middle East, North America, and South America. Paying customers are clearly crucial for the profitable operation of the business, but are not necessarily easy to find for a small niche firm originating from a small country. FinnBiotech had a good start in acquiring customers because of its founders' connections. The

Managing Director had excellent international connections form his previous role as the R&D Manager of Finland's largest diagnostics company. Another of the founders also had outstanding connections and experience in marketing as he had occupied the role of Marketing Director of Finland's largest diagnostics company. He assumed the role of Marketing Director at FinnBiotech, and, in addition to his contacts, brought with him a strong appreciation of the importance of market-orientation and marketing.[43] As two of FinnBiotech's founders came directly from a large diagnostics company, they were able to use the customer connections they had developed at that company to acquire the first customers for FinnBiotech. Therefore, FinnBiotech's first customers were also the large diagnostic company's customers. This was possible because FinnBiotech's product did not directly compete with the large diagnostics company's offerings. Indeed, the large diagnostics company had turned down further development of the technology and sold the intellectual property rights to FinnBiotech.

As a result, FinnBiotech has been able to succeed with minimal investments in marketing, gaining further customers through word-of-mouth and references. In this way, FinnBiotech was gradually able to gain recognition and respect in the market, which facilitated its success in gaining new customers at industry fairs. Indeed, industry fairs have been the main means of gaining new customers throughout FinnBiotech's history. Nearly all customer contacts are generated at industry fairs, and about half of these turn into actual paying customer relationships. The fact that FinnBiotech has had excellent customer references from the beginning has played a large role in how effective industry fairs have been for the company in terms of gaining customers. Quite soon, because FinnBiotech regularly attended the same large international industry fairs, the majority of other people in the industry became familiar with the company.

Hence, attending industry fairs quickly started to become effective when the company depended less on hoping that someone would be interested in the company's stand, and instead began to arrange a plethora of meetings with existing customers and contacts. As FinnBiotech is so active in attending international industry fairs every year, meetings can even be arranged from one industry fair to the next, thus make networking even more effective. For example, one year the R&D Manager had engaged in conversation with potential Indian customers at an industry fair in Dubai, and when the Export Manager attended an industry fair in India a short time later, he contacted

[43] This person is the one who sadly passed away before beginning of this study, and information about him is therefore only at second-hand.

these potential customers and was able to turn them into existing customers at the fair in India. Industry fairs around the world are an effective networking tool for contacting potential and existing customers, as they save time and money that would otherwise be spent on air travel to visit each potential and existing customer individually.

There are a couple of large industry fairs that "everyone attends." Everyone is aware of the existence of these industry fairs and of how important they are. The Managing Director and the founding Marketing Director gained this information during their time at the large diagnostics company, and the decision to attend these industry fairs was clear. However, it is not always so straightforward to know about all possible industry fairs taking place internationally, especially if they are new or highly specialized. It can be even more difficult to know whether these fairs are worth attending. Therefore, it is important not only to learn how to network at industry fairs, but also to learn which industry fairs are worth visiting. It can be a considerable waste of money and time for a small company to attend an industry fair where there are no promising potential customers. Moreover, it is important to learn which industry fairs best serve which purpose: some industry fairs are best for acquiring R&D information, whereas others are best for acquiring information about customers. This theme came up in interviews again and again: several of the interviewees remarked that while communication skills, social skills, and perseverance are extremely important in winning customers, a good level of technical expertise makes meaningful discussion much easier. Such technical expertise makes it possible to ask better questions, to gain a better understanding of customer needs, and to explain the benefits of FinnBiotech's products.

Although the industry fairs have maintained their crucial position in the industry despite the advent of the Internet and e-mail, digital communications are heavily used. The Internet is used to check the backgrounds of potential partners and to provide an easy way for those who may not have had time to talk to FinnBiotech's representatives at an industry fair to find out more about the company's products and make contact. Similarly, after first establishing contacts at industry fairs, FinnBiotech's representatives then do detective work online to determine the current product portfolio of potential customers in order to tailor their offer better. Similarly, e-mail is a very important communication medium, both for communicating with potential customers and for settling details with existing customers. Proposals and all of the information that needs to be attached to them are communicated via e-mail: the extensive scientific documentation

related to tests, terms of delivery, negotiations about packaging, terms of payment, and so on are all delivered via e-mail.

Nonetheless, while the heavy use of digital communications is clearly very important in business operations such as those of FinnBiotech that are spread all over the globe, they complement rather than supplant face-to-face communication. This is probably why industry fairs, which may seem old-fashioned, have retained such an important position in the industry: they enable many people from all over the world to meet face-to-face, while reducing the time and money required for air travel. The Export Manager described this importance of face-to-face contact even in a world that is by necessity heavily reliant on digital communications:

> *"We communicate a lot by e-mail, but at an industry fair, you get to look in the other person's eyes and better figure out what they are thinking."*

However, although FinnBiotech has been successful in gaining customers and acquiring information about them (especially at industry fairs, and through the networks formed and maintained at industry fairs), these customers are only business-to-business customers. The significance of this is that FinnBiotech is several intermediaries away from the end users of their products, putting them at a disadvantage in terms of prices and of knowledge of end users. To be able to succeed in profitably selling its products, FinnBiotech needs to have knowledge not just about its direct customers, but also about end customers, prices, and healthcare systems around the world. As the Managing Director aptly put it:

> *"To develop, introduce, and market new products, it is necessary to know the processes concerning the introduction and use of these products in various markets around the world. It is necessary to know how to operate profitably in each market and how to develop business in each market. To do this, one must not only be able to operate with customers, but have knowledge of competitors, technologies, new product adoption processes, and the functioning of the healthcare system in each market."*

FinnBiotech's distribution network typically includes two to four intermediary companies between FinnBiotech and its end users. At its longest, this distribution chain consists of four intermediaries: the first intermediary—and FinnBiotech's immediate customer—is an importer, wholesaler, large pharmaceutical company, or a diagnostic company. This first intermediary then sells the products to a local distributor, this being the second intermediary. The local distributor sells the products to laboratories, physicians' offices, retailers, and/or pharmacies, these being the end users in the former two cases, or third intermediaries in the latter two cases, who then sell the tests to consumers.

The Managing Director, especially because of his prior experience at a large diagnostic company with its own sales subsidiaries, is very aware that this lengthy distribution chain is a disadvantage to FinnBiotech. However, FinnBiotech is too small to take the risk of establishing its own sales subsidiaries as these would require very high and regular sales volumes. FinnBiotech's profitability clearly suffers when many intermediaries are involved, as each takes a cut of the profits, leaving FinnBiotech only about 10-15% of the price at which the product is sold to the end user. Moreover, this long distribution chain isolates FinnBiotech from much of the information it needs to know about markets and end users.

Certainly, by far the primary source of information about markets are FinnBiotech's customers. As the Managing Director says:

> *"Market information comes from customers; it is important to listen to customers, to their suggestions and wishes."*

Customers also provide information to FinnBiotech about other market participants, so that references from existing customers can help in finding and choosing new customers. Thus, information and customers create a virtuous, self-reinforcing spiral: as the number of customers has grown, the company has increasingly received information through them, which has helped them get more customers. However, the problem is that as the customers are often FinnBiotech's only direct information source in its various markets, FinnBiotech is dependent on its customers and on the information they provide.

The customers only provide information when it benefits them: for instance, they will let FinnBiotech know if there is demand in a particular market for a product that FinnBiotech is developing, but will not divulge information about possible volumes or prices of similar products in the

market. Therefore, FinnBiotech can be at the mercy of its customers in terms of information about markets. Such information would include information about overall volumes, end customer prices for classes of products (both competitors' products and FinnBiotech's own products) in the markets, trade prices between the intermediaries, general profit margins of the various intermediaries, possible competing customers in the same market for FinnBiotech's products, and end users' experiences of FinnBiotech's and competitors' tests. Keeping FinnBiotech in the dark about such matters gives its customers power and leverage in price negotiations with FinnBiotech. As the immunodiagnostics market is very cost-conscious, and part of FinnBiotech's competitive strategy is to provide good quality at decent cost, information about prices would be tremendously valuable. As it is, with FinnBiotech often ignorant about price levels for end customers in different countries, as well as about transfer prices between intermediaries, it is easy for customers to push FinnBiotech's prices down in negotiations by claiming that they could get a better deal from a competitor. The Managing Director described this in the following way:

> *"Useful, valuable pieces of information are hoarded because there is high price awareness in the market and prices are talked about a lot.... It is thus sensible that information about prices is kept hidden."*

Moreover, it would be *"worth gold,"* as the Export Manager put it, to have knowledge about how end users use and experience FinnBiotech products, how product quality and especially the price/quality ratio are perceived, how easy-to-use and reliable the products are, and how the users perceive the products. It would also be valuable to know how various segments of end users differ, for instance in their price sensitivity, behavior with the product, the point-of-sale, and the purchase decision criteria. All of this information would be of great value for R&D but, as the Export Manager put it:

> *"Feedback from end users ... comes only through distributors. It is necessary to pump them to get any of this information. This information gets lost on the way, as intermediaries do not have an interest in passing it on because they want to keep this information to themselves to be able to maintain control over the producers. The only thing that they do*

communicate back is complaints, as this also gives them more power in negotiations."

FinnBiotech has devised several ways to get around the intermediaries' desire to keep FinnBiotech in the dark and to gain information about prices and end users, although none of these has been able to correct the problem completely. This market information is rarely sought in consulting and market research reports, because they have been found to be "*expensive, superficial, and not very reliable*," in the words of the Managing Director. Sometimes information about markets can be received from public research institutes, export promotion agencies, and non-profit organizations, but typically the information needs to be further analyzed, evaluated, and often combined with other information before conclusions can be drawn. Sometimes, knowledge about markets can be developed through own analytical work using public databases, as the Managing Director described:

"Based on public statistics, much can be inferred about markets, for instance about market potential. … Similarly, based on public documents, quite a lot can also be learned and inferred about competitors and product end prices in some markets, especially if you analyze and combine data from various sources."

Sometimes important information is stumbled upon: in one case, the local partner seemed sincere in not having information about the market potential for a certain infectious disease test in China. However, with a little work on the Internet, it was possible to find public statistics, from which the prevalence of this disease, and therefore the theoretical market potential for a test diagnosing it, could be inferred. However, finding information in this way requires time and skill, and it is necessary to check that the information is correct. Indeed, any decision made by the management team members at FinnBiotech is based on information coming from several sources that is in line with experience and general appraisals.

Although Finnbiotech's own analytical work can provide quite a lot of the information that the customers keep from FinnBiotech, the best information about markets and customers comes from personal contacts. However, interesting here is that personal contacts do not intentionally pass on confidential knowledge. Instead, it is from personal interactions and

discussions that one can infer things when alert. The Managing Director illustrates this:

> *"Important information relating to market conditions, especially prices and end users, comes in small pieces that are spilled accidentally, mostly in informal situations, such as in lunch conversations. … If you can connect one small piece to something else, you can figure things out."*

The Managing Director went on to emphasize the importance of network connections as sources of relevant information of the kind that market actors do not want to share openly:

> *"You can get information from several places, but specific information comes from contacts. And the more you travel and interact with people, the more contacts you have."*

However, the Managing Director still emphasized the importance of alertness in FinnBiotech staff, noting that they could not simply rely on contacts feeding them the information they needed:

> *"Even when listening to contacts, you need to figure out what is valuable, reliable information, because there is a lot of superfluous information. Only a small part of what you hear is relevant. There are a lot of rumors in the markets, and you need to evaluate them for yourself to figure out if there is truth to them."*

Such personal interaction needs to take place around the world, as this information about market conditions is—understandably—distributed around the world as well. Therefore, frequent air travel is a necessity for the management team members. The primary purpose of most trips is to meet customers, but while in a certain country, the management team members try to maximize the benefits of their presence. They try to find out more about the actions of competitors in different markets and to gather information about end prices of products in the various markets, if only by visiting pharmacies and seeing what is on offer and at what prices. They also aim to learn more about the healthcare systems of particular countries and to meet relevant

individuals. For instance, the Export Manager was once driving back through Poland from an industry fair in Germany, and arranged to visit the Polish subsidiary of a company whose headquarters in Germany were already FinnBiotech's customer. The visit paid off in a deal with the Polish subsidiary, as well as in contacts for the company's Hungarian subsidiary, which also ended up buying the test. Another time, the Export Manager was vacationing in Argentina and had set up a meeting with FinnBiotech's Argentine customer before the trip, as well as contacting the commercial arm of the Finnish Embassy in Argentina. As a result, the Export Manager was able to gain two new local customers from his holiday.

However, one of the most important functions of these multiple personal contacts and travels around the world to visit potential and existing customers and other business partners, and to observe the competitors and the market, is to form an overall perception of where the industry is going. This makes negotiations with customers easier and widens horizons as to business opportunities. It is crucial to try to create a holistic view of industry dynamics and trends, and at the same time to try to make sure that the information gathered is correct and that FinnBiotech is able to use it. Indeed, it is in this area of information about customers and markets that arguably the most uncertainty and lack of information exist, not because information about customers and markets would be complex, difficult, or highly tacit, but because it is so tied up with power and profit.

4.1.6 Information about Quality, Regulation, and Patenting

FinnBiotech's industry sector is highly regulated. The tests must comply with the regulations, which are proliferating as point-of-care tests are becoming more common. For instance, concerns over the quality of point-of-care tests have resulted in a hierarchy of regulations in a number of countries. A bevy of standards and regulations dictates the quality of tests and their production. This means that everything about the tests and their production must be carefully quality controlled and documented. Based on this documentation, the tests can receive CE markings that allow them to be sold within the European Union, and FDA registration that allows them to be sold in the United States. Beyond these countries, the tests typically need to be registered separately for each country in which they are to be sold. Moreover, the markings on the test packaging and the instructions accompanying each test must typically be translated into the language of every country in which the tests are sold. Meeting all these demands takes substantial amounts of time

and money. Indeed, overcoming the multiple regulatory hurdles impedes market entry of innovations from smaller companies in particular. This problem is multiplied when a firm sells its products in dozens of markets around the world, as FinnBiotech does.

However, it is the duty of public officials to make clear the procedures and materials required for receiving regulatory approval and, as the Quality Manager put it, "legislation concerning registration is quite clear." Indeed, while most of the information about documentation and registration can be quite easily accessed from public officials as it is part of their job to distribute this information publicly, the challenge is in distilling this plethora of information and making sure important bits are not lost in the process. As the Quality Manager described it:

> *"Information about legislation comes from public officials. … There is a lot of information but it can sometimes be a bit difficult to get because for instance directives rain from the EU so it is necessary to be able to pick out the right information."*

Indeed, although FinnBiotech's Quality Manager, who is responsible for regulation issues, is a scientist, she has been able to handle the legal part of registration processes. Although this has required some determined learning from her, she considered that *"the legal texts are clear enough that it is possible to handle registration documents without a lawyer's training."*

Also, information about regulation in different countries is received from customers, as they are knowledgeable about their local systems and have an interest in communicating information about specific local regulatory demands to FinnBiotech to ensure that the products can be sold in their market. They also often deal directly with local officials on behalf of FinnBiotech because once they have made the purchase decision, it is in their interest that local regulatory demands are satisfied as quickly as possible in order to get the product to market. However, even the local distributors face problems, or at least claim to, as the Quality Manager explained:

> *"Sometimes getting a product registered is a challenge. For example, in Argentina, the process of getting our product registered has taken nearly a year, because the public authority handling this constantly requires something new, just because it is a way for them to earn money. Our local*

distributor is handling this, as a local firm usually knows the customs of a country, such as the need to take a public official out to dinners and so on. So we just have to trust the local company, but we do not really know if we can. For instance, in Argentina, we do not know if sales will ever be able to start. We definitely have to take risks in trusting local distributors."

Moreover, while customers often help with navigating the public authorities' registration and documentation demands, they can also have additional demands of their own. For instance, certain markings on test packaging are mandatory in European Union countries, but customers will often want their own markings on the packaging, and sometimes also require the instructions to be printed with their logos and brands. Sometimes this is simply not possible because of regulatory demands, so FinnBiotech also needs to educate their customers as to what regulation requires.

Information about patent legislation is, however, quite a different matter. Throughout most of FinnBiotech's history, the company has had no major problems with patents as the regional market areas in which it has done most of its business—Europe, Asia, the Middle East, and South America—have not had traditions of aggressive patenting. However, the entry of U.S. competitors into Europe has introduced entirely different dynamics. U.S. companies have used patenting as a strategic competitive weapon. They have threatened competitors with lawsuits claiming infringement of their patent rights, and the legal costs of fighting such a suit in court has persuaded smaller competitors, such as FinnBiotech, to settle out of court. Even though FinnBiotech would probably have won its legal battle against a U.S. company, the threat of an extremely costly legal battle was enough to cause FinnBiotech to back off. The use of patenting lawsuits as a hostile strategic weapon is an area in which FinnBiotech has had little exposure. The company lacks knowledge as to how best to maneuver and is only now beginning to acquire the necessary information.

4.1.7 Facilitating Factors in International Information Acquisition

Tendencies for affiliating with other actors for information acquisition were not driven by shared national culture or geographic proximity. Instead, primary facilitating factors for information acquisition appeared to be shared

experience in the diagnostics industry and similar educational backgrounds. As the Export Manager explained:

> *"There is quite a strong industry culture that is outside of national cultures. We are all part of the diagnostics industry, and these shared experiences help us understand each other."*

The Production Manager echoed this, stating:

> *"People in the diagnostics industry have developed their own culture. Thus, when dealing with other people, it is easiest to communicate with others who have been involved in this industry for a long time and are familiar with it. National cultures do not have much influence on our interactions. Rather, it can be difficult trying to communicate with someone unfamiliar with the industry. This is true even for individuals coming from a related industry, such as functional foods or pharmaceuticals."*

The R&D Manager also emphasized the importance of shared work experience in the diagnostics industry as a facilitating factor for interaction and communication. He also highlighted the importance of similar educational and professional backgrounds:

> *"To an extent, it might be easier to communicate with other people from the Nordic countries, but this is not really a big deal. No, national cultural differences are not really felt that much. If there seem to be any differences, they are more saliently among those of different educational and professional backgrounds. So for instance for me, with a scientific training, it is easiest to communicate with others from science backgrounds. By contrast, someone from a commercial background, and holding an MBA, for example, may seem foreign and to be speaking a different language."*

4.2 NARRATIVES

4.2.1 Successful Outcome Narratives

Narrative 1: New Product Development

Abstract: A very successful event was the development project for the test for celiac disease, currently the company's second most important product.

Orientation: FinnBiotech wanted to develop this particular kind of test and had worked on it before, but had not succeeded. Then, someone from the technology transfer institute of the University of Tampere in Finland got informally in touch with FinnBiotech regarding an invention for diagnosing celiac disease that had been developed by a professor at the University of Tampere together with a scientist from Hungary. The University of Tampere technology transfer institute had patented the invention and wanted to commercialize it on behalf of the scientists. The Director of Business Development at the technology transfer office contacted FinnBiotech because he was previously familiar with the company, having met FinnBiotech's R&D Manager before at an industry fair in Germany. After this, FinnBiotech received more detailed information about the invention through the technology transfer office. Then, very quickly, FinnBiotech's R&D Manager and Managing Director got in direct contact with the scientists who had developed the invention. The invention was tried out at FinnBiotech, but it did not work. However, after exploring the situation and being in more contact with the inventing scientists, the R&D Manager at FinnBiotech realized that there had been a misunderstanding and there had been an internal error at FinnBiotech. After correcting for this error, the invention worked well.

Complicating action: At this point, the University of Tampere technology transfer office was contacting several companies in Finland and abroad to find a suitable licensee for the invention. FinnBiotech was very keen to license the invention and it was perhaps this enthusiasm which won them the license, although the fact that the technology transfer office was looking to commercialize the test in a rapid test format also meant that FinnBiotech was a strong contender. As a result, FinnBiotech succeeded in licensing the invention. After the contract for licensing the invention had been signed, there was very close cooperation between FinnBiotech's employees and the scientists who had developed the invention. FinnBiotech's R&D Manager was in touch

with the inventing professor nearly weekly for several months in order to share information. The scientists also came to visit FinnBiotech to educate FinnBiotech employees about the disease, the scientific research, and the invention that had been developed.

Evaluation: Things worked really well because, in addition to the technology, the scientists who had developed the invention also offered the clinical testing results. The scientists had also published in several journals and presented papers at conferences. They were attending various events, talking about the new product and where it could be obtained. This was not intentional sales or marketing and the scientists did not have any contract with FinnBiotech to do such marketing. It was simply that the professor had spent his entire career on this and was passionate about getting the test out to markets where it would benefit child healthcare, in which he was specialized. Over his long career, this professor had also established himself as one of the world's foremost celiac disease researchers, and therefore had a wide contact base, which helped generate sales. This professor was, therefore, a leading "sales person" for the test, apparently not because of monetary incentives but because it was his personal ambition to get his own invention into use worldwide to help patients. This was also probably because through his work with patients, he had observed that a rapid test for celiac disease would help patients, especially children, but none had been available before his invention. The professor and his collaborating scientist were also able to provide the scientific and clinical research needed for quality registration, so the invention could be rapidly turned into an innovation ready for sales because the scientists provided a ready-made product together with documentation about scientific and clinical tests and user tests. It would not have been possible to turn the invention into an innovation and to start selling it, at least not so rapidly and successfully, without their input.

Resolution: When FinnBiotech launched the celiac test, its revenues grew significantly, both from existing customers buying the new product and from new customers attracted to the company by the new product. The rapid test for celiac disease was a very competitive product and easy to sell because it was unique. This also meant that it was possible to get a good price for it because there were no competitors and no substitute products. The test was also easy to use and had a strong and credible scientific backing as there were so many scientific publications about it. This scientific background helped to make the product well known in Europe, so that it was easy to begin sales. Moreover, even in markets outside of Europe, there has been great demand for the

product because of its uniqueness and for example a distributor in the Middle East has set up a training center dedicated to educating the public about celiac disease in order to create markets for this test.

Coda: This product has been a great success because of its uniqueness, its strong scientific backing, and the fact that the scientists who developed it have acted as its "sales persons" by talking about it in international conferences and telling their contacts about it. It is now one of FinnBiotech's most important products.

Narrative 2: New Product Development and Expansion to New Markets

Abstract: FinnBiotech established a facility to develop rapid tests for cancer in a joint venture with South Korean partners where FinnBiotech is the largest owner with a 20% stake. The joint venture also involved building a factory in South Korea for manufacturing existing FinnBiotech tests. To build the factory, FinnBiotech sold production knowledge and expertise to its joint venture partners and was in charge of the technology transfer from Finland to South Korea.

Orientation: The connection came through the Soviet Union in 1988-1989. A Russian man from Moscow was visiting Finland. He came to visit FinnBiotech and wanted to begin selling the company's tests in the Soviet Union. He had heard about FinnBiotech from his sister who was working in Finland. He looked like "Rasputin" and said he had no money, so I (the Managing Director) thought that if a man is honest enough to admit that he has no money, it is worth the risk, so I gave him five hundred tests to sell. He sold the tests in the Soviet Union and cooperation began this way. He also had a friend in South Korea who wanted to begin selling FinnBiotech's tests in South Korea, which I (the Managing Director) agreed to.

Complicating action: This co-operation with our South Korean contacts then deepened in the 1990s so that FinnBiotech founded a joint venture in South Korea to develop rapid tests for cancer and to build a factory there to produce existing FinnBiotech tests. It turned out that both the Russian man and his Korean friend were connected to many highly positioned researchers and officials in the Soviet Union—now Russia—and in South Korea. The Russian man had had freedom to travel during Soviet times because his father

was a leading cancer researcher in the Soviet Union and his grandfather belonged to the Academy of Russia, and he had in fact been returning from a research visit to the National Institutes of Health in the United States when he came to visit Finland. That is also how he knew the Korean man. It turned out that the Korean contact belonged to a very highly positioned family in South Korea, and since hierarchy and families are very important for trust there, this helped very much in establishing contacts and in getting the South Korean government to support the venture. That is also how the South Korean joint venture has been able to become affiliated with a Nobel Prize–winning cancer researcher, as he was the Korean contact's research mentor at the National Institutes of Health in the United States. To accomplish the technology transfer for building a factory in South Korea for the production of existing FinnBiotech tests, and the rapid tests for cancer if their development was successful, two people from Korea came to study in Finland for a month. They were taught how to operate the equipment sold to them by FinnBiotech. They spent one month in Finland and were taught the entire process. The two people were given all the training related to the tests and their production, and they produced a few model batches together with FinnBiotech employees to make sure they had mastered the necessary processes. FinnBiotech employees carried out work tasks with them from beginning to end. Also, once the factory in South Korea was built, FinnBiotech employees went to visit and suggested improvements, provided help if there were problems, and provided further assistance and information.

Evaluation: I (the Managing Director) figured that even if we lost five hundred tests to the Russian man if he turned out to be unreliable, it would not bankrupt us, but if things turned out well, there could be considerable potential. After all, he had made the effort to find us and was interested in our tests. So I thought, "Why not?"

Resolution: So now we have the joint venture in South Korea and also have important contacts in the United States and in Russia. We are working on developing rapid tests for cancer in South Korea and also manufacturing other FinnBiotech tests there, so that if the production in Vantaa is busy, it is possible to source tests from the South Korean factory, and FinnBiotech also sells raw materials to the factory in South Korea.

Coda: The Russian connection was dormant for a long time, but in 2005-2006 the man contacted FinnBiotech again and said that his mother was interested in FinnBiotech's helicobacterium test, because she had been put in

charge of public healthcare in Moscow where the Russian government was financing extensive testing for public health, and she wanted to use FinnBiotech's rapid test for that. So new cooperations and opportunities keep coming up from these connections.

Narrative 3: New Product Development

Abstract: FinnBiotech had been sued by a U.S. company who was implementing a very aggressive patent strategy in order to gain market space in Europe. It was driving competitors away from markets by threatening them with patent litigation. The U.S. company also took FinnBiotech to court, claiming that FinnBiotech was infringing on their patent. This meant that FinnBiotech was suddenly in the position where it could no longer produce and sell one of its most popular tests.

Orientation: The motive for product development, therefore, was the urgent need to develop a new product version that could not be claimed to be infringing on the U.S. company's patent, so that FinnBiotech could continue selling this type of test. Otherwise FinnBiotech's sales would have crashed.

Complicating action: FinnBiotech was in a huge hurry because it was facing a crisis and needed to come up with a new product really quickly. The idea for the new product version was clear because it was necessary to develop a version that would not infringe on the U.S. company's patent.

Evaluation: FinnBiotech was able to develop a new test very quickly and thus avert the crisis because its product development function was so strong. But as it was in such a hurry to develop a new product version, there was not sufficient time to listen to customers.

Resolution: A new product version was quickly developed for sale, but many customers disliked the product because it was so different from the traditional version.

Coda: Customers have realized that if they want to buy this type of product within Europe, they have to buy the version that does not infringe on the U.S. company's patent, even if they do not like it as much.

Narrative 4: Expansion to New Markets

Abstract: FinnBiotech acquired the operations of a company subsidiary developing ELISA tests to widen its product portfolio. The acquisition gave FinnBiotech already developed ELISA tests, related production technology, and resources to develop these new kinds of tests to strengthen its business.

Orientation: I (the Managing Director) was familiar with this company because it had originally been a Finnish startup that had then been acquired by a U.S. company. However, now the U.S. company had decided to sell this part of its business. A hint of the U.S. company's intentions came from an Indian contact before the U.S. company had made its sales desire public. The Indian man had an interest in seeing FinnBiotech purchase these business operations because then he could get more custom from us.

Complicating action: At first I was not interested. However, then we had the big patent dispute that showed how vulnerable our business could be if it relied on a product portfolio based on a single technological platform. I thought that it would be good for business stability to have another supporting leg. So the U.S. company was contacted and the decision made to purchase the operations.

Evaluation: So the hint turned out to be valuable and the Indian man has profited from it himself, as he now sells ingredients for both of our product lines.

Resolution: In 2004, the operations were merged and now FinnBiotech has a wider product portfolio and another technological leg to the business, which makes it more secure and stable.

Coda: FinnBiotech's business expanded and we began developing new tests based another technological platform. We now also have a joint venture in China that came with the acquired ELISA business operations, and we are also negotiating with the company that sold the business about co-operation in the United States.

4.2.2 Less Successful Outcome Narratives

Narrative 5: New Product Development

Abstract: A less successful example is a prior project for the development of a celiac test where FinnBiotech worked with an Italian company, but just did not manage to develop the desired product.

Orientation: The Italian company had a celiac test in ELISA format and wanted to develop a rapid test version of this test. We (FinnBiotech) started developing a celiac test for them in 2001. It was a product development project that the Italian company paid for; there was a down payment and then payments according to progress. We agreed on the development and also about things after it, like production, sales, and so on.

Complicating action: We basically cooperated so that the Italian company sent us material about their test, but their idea did not work when we tried it. We worked on the project for about three years and the money we received was spent many times over. We made a prototype but the Italian company did not approve it because the test was not sensitive enough. We tried to solve things through cooperation, which was very close and involved highly trained product development scientists from the Italian company, and we worked together with them to try to solve things.

Evaluation: The cooperation worked, they constantly gave us new ideas and lots of know-how that had been generated when they developed the ELISA test. It felt like they were really open in their communication, but things just did not work out. So the communication and cooperation were good, but the outcome was not. The cooperation worked, we were constantly in touch, it wasn't because of that. They gave everything they could give and thought about things at their end, it wasn't that. It just didn't work.

Resolution: We just did not get the product to work at acceptable sensitivity levels and abandoned the project.

Coda: So, despite good communication and cooperation, we were not able to develop the desired project. Instead, we lost money on research and development. But now we have the celiac disease rapid test that we developed

with the Finnish and Hungarian scientists, so we were able to get a celiac test into our product portfolio in the end.

Narrative 6: New Product Development

Abstract: Some product development projects have started with an idea or inspiration received from a contact. There has been excitement about trying this new thing out, but the knowledge has been lacking to the extent that the project has just not worked.

Orientation: There have been quite a few projects where an exciting idea has come through a fleeting contact, and we (FinnBiotech) have tried to work on it and develop it into a test. But in many cases where the idea just comes from someone with whom there is no longer-term direct contact, the knowledge has been so insufficient that the project just has been impossible.

Complicating action: Ideas often come from fleeting contacts; for instance, scientists presenting at scientific conferences, a discussion with someone, and so on. They may seem exciting so we have tried to take them into account and develop new products based on these ideas. However, where we have not had a direct link, especially over a longer period of time, to the person who originally developed the idea, we have had no access to the original information and have been unable to ask the developer why initial trials failed and how to continue development.

Evaluation: In these cases, we just simply have not had enough knowledge to develop the product. The project has been impossible from the start because of our insufficient knowledge, and inability to acquire it from the original developers of the idea.

Resolution: Product development projects like these have simply not worked out because of the lack of knowledge and communication.

Coda: It is good to have lots of contacts because we need to hear lots of ideas, but it can be problematic if those who should develop the product do not have direct contact with the idea's original developers, but have only heard about the idea through someone else.

Narrative 7: New Product Development

Abstract: Sometimes information could have arrived sooner, as we (FinnBiotech) have been caught in situations where our products have been outdated in the market because we had not been aware of the latest scientific knowledge.

Orientation: In some cases, we have been alerted by a customer that we have had a product on the market that has become outdated because of new scientific research of which we have been unaware. Sometimes we have launched a new product on the market, and have then heard from a customer that someone has already done this thing. The scientific information had been available, but we had not been aware or it.

Complicating action: In situations like these, since we had not known about the latest scientific research, our competitors have had an advantage because they have had an earlier start to developing a new product, or they have had better and more up-to-date products on the markets.

Evaluation: Maybe related to such things one could think that the contacts to universities are too weak, that we do not have a designated person at a university that would constantly communicate the latest research to us.

Resolution: So, then, we have sought out the information and we have developed a new product version, but a little late.

Coda: One does hear about things, but sometimes a little late. Maybe we should think about having closer ties to universities, especially a "trusted man" who would be our constant contact to what is happening in science.

Narrative 8: New Product Development

Abstract: It's great that we get new product ideas from customers, but there have been a few cases where we (FinnBiotech) have come to realize that the suggestion has come too late.

Orientation: One of our customers suggested that we develop a certain kind of a rapid drug test, as the customer wanted to have such a test in its product portfolio. This seemed like a good opportunity, because we knew that the demand for drug tests was growing and that we would have a customer ready for our test. So we started looking into it.

Complicating action: However, after some research and development, we realized that a competitor already had a similar test in the market. The product was already established, and it was not worth our while developing our own product.

Evaluation: Unfortunately, the idea came too late. It was a good idea, and if we had received it earlier, it could have made a valuable addition to our product portfolio and strengthened our relationship with this customer.

Resolution: We had to tell the customer that it was not worth starting to develop a product for the market and we did not develop the product.

Coda: If ideas come so late that competitors have already had similar products on the market for a while, the idea for a new product must be rejected because it is known that the market is mature and competitive and prices are thus low. It is just not worth starting to develop such a product.

5 CONCLUSIONS

5.1 REFLECTIONS ON INNOVATION IN MODERN BIOTECHNOLOGY

Innovation in modern biotechnology has been characterized in the literature as highly collaborative, taking place especially between universities, small dedicated biotechnology firms, and large established corporations (Dodgson, 1993). The role of universities has been argued to be central, because inventions in modern biotechnology are built up over long periods of time in the realm of basic publicly funded science (McMillan et al., 2000; Zucker, Darby, & Brewer, 1998), demanding industry actors to collaborate with universities to gain access to information concerning the latest scientific developments (Rothwell & Dodgson, 1991).

The central role of universities in modern biotechnology innovation has been posited to be largely the reason behind the continued importance of small dedicated biotechnology firms in the sector (Kenney, 1998). Small dedicated biotechnology firms are argued to have several competitive advantages in modern biotechnology innovation vis-à-vis larger firms, because they are said to be better than large firms in transferring information from universities (Dodgson, 1993). This is posited to hold because small dedicated biotechnology firms are typically closely attached to universities and have a significant emphasis on research, making it easier for them to collaborate with, and recruit, the best scientists from universities (Kenney, 1998). Small dedicated biotechnology firms are also said to enjoy a number of behavioral advantages over their larger counterparts in innovation, such as rapid response to external threats and opportunities, efficient internal communication, and interactive management style (Rothwell & Dodgson, 1991).

Small dedicated biotechnology firms have also been noted in the literature to suffer from a number of mainly material disadvantages, particularly debilitating being their lack of complementary assets necessary to attain full returns from innovation, such as competitive manufacturing, marketing and distribution networks, and ability to deal with the regulatory procedures in getting new products on to the market (Rothwell & Dodgson, 1991). As a result, it is noted in the literature that small dedicated

biotechnology firms often collaborate with larger firms in order to gain access to such complementary assets (Kenney, 1998). Thus, these university–small dedicated biotechnology firm–large firm collaborations are posited to create innovation systems characterized by synergies in networks of organizations (Dodgson, 1991a). Finally, particularly in the United States, venture capitalists have played an important intermediary role, helping small dedicated biotechnology firms access funding and create relationships in order to access complementary resources for innovation (Kenney, 1998). The relative dearth of venture capitalists in other countries has been seen as a major challenge (Ward & Hodgson, 2006; Ward et al., 2005).

The role of universities in innovation at FinnBiotech was much more circumscribed than may have been expected based on the literature. It is indisputable that FinnBiotech was created around inventions that arose from the public science base as a result of scientific developments over a long period of time. It is also indubitable that the transfer of this scientific knowledge to FinnBiotech was localized, taking place through the personal participation of FinnBiotech's founders in a project aimed at developing inventions and innovations from advances in the science base. These are in line with what could be expected based on the literature. However, unlike in the United States and the United Kingdom, where the founding of small dedicated biotechnology firms has closely followed the location of star scientists and world-leading research departments (Bud, 2010; Zucker & Darby, 1995, 1996), in the results from FinnBiotech, the involved science base was largely transferred from abroad through the Finnish government's efforts rather than pioneered on the spot. Certainly, the transferred scientific knowledge built on long-term strengths in Finnish science, which made the successful transfer possible, and the transferred science was developed further to create original results. Nonetheless, this suggests that it is possible to develop successful innovations in a science-based sector even when the underlying science is not pioneering in the specific locale, but instead largely transferred from abroad.

While universities played a key role in the initial emergence of FinnBiotech and its innovations, their role deviated from what might have been expected as the firm matured. Simply put, universities played a much less significant role in innovation at FinnBiotech than may have been assumed based on literature. Certainly, scientific research conducted at universities was a *sine qua non* for innovation at FinnBiotech, but this only provided a generic background to innovation. Of course, it is worth pointing out that at times FinnBiotech may have been excessively nonchalant about keeping up with developments in science. The narratives (especially Narratives 7 and 8)

suggest that it was the failure to have been informed about latest advances in science that had at times resulted in the company having outdated products or being late in seizing new opportunities. Moreover, the narratives (especially Narrative 1) suggest that while the interviewees at FinnBiotech did not consider universities to have provided them with much information that could be used directly in product innovation, the firm had received quite a full package of information for one of its most successful products from a university. While these results may be interpreted as FinnBiotech's management team members slightly underestimating the importance of university science to innovation at FinnBiotech, their perception that universities provide only a distant and general background to innovation at FinnBiotech cannot be ignored. The results did suggest that often the distance between scientific knowledge generated at universities and the creation of successful innovation was very long and required much additional information and knowledge.

Much of the most directly relevant scientific information that fed into innovation at FinnBiotech came from FinnBiotech's suppliers, not universities. These suppliers were most likely not the original creators of this scientific knowledge, but information intermediaries who performed the function of monitoring information generated at universities, sifting out the parts relevant to these particular products, and bringing the information closer to practice by using the latest scientific knowledge to keep their products up to date. Thus, FinnBiotech was able to receive from them filtered and focused information of latest scientific advances directly relevant to their products, and the suppliers had already carried out significant work in converting this scientific knowledge into products. Considering that the interviewees, especially the Managing Director and the R&D Manager, strongly emphasized that the main challenge faced by the firm in generating innovation was in translating scientific knowledge into products, this service provided by the firm's suppliers was significant. In other words, the suppliers could be seen as having already carried out some of the translational work necessary to bridge the distance between science and products.

FinnBiotech's relationship with large firms, the other main set of organizations noted in the literature to be important collaborating partners to small dedicated biotechnology firms in addition to universities, deviated entirely from what might have been assumed from the literature. The literature suggests that small dedicated biotechnology collaborate with large firms in order to gain access to complementary resources, such as manufacturing and distribution (Dodgson, 1993; Kenney, 1998). However,

FinnBiotech had no such large firm collaborations. While the interviewees described this as a strategic decision by the firm management, it also seemed to have been a decision very much driven by the realities of the context, these being the lack of suitable partners.

FinnBiotech had been forced to develop its own manufacturing competences because the manufacturing capabilities necessary to produce the tests created at FinnBiotech simply did not exist in the market when FinnBiotech began producing its tests in 1990. Neither was there a suitable partner that might have developed these manufacturing competences on FinnBiotech's behalf. Intriguingly, it did not appear that FinnBiotech looked for one very intensively. This could be because FinnBiotech could develop its own manufacturing competences quite easily because it was able to access information, knowledge, and expertise necessary to do this from existing organizations in its home market. When FinnBiotech began its own manufacturing of the tests it developed in the 1990s, both the product and its manufacturing were pioneering enough to command prices that made manufacturing in Finland at a relatively small scale competitive. Having been forced to develop manufacturing competences in-house shaped FinnBiotech's subsequent manufacturing decisions. Even when reliance on internal manufacturing began to present challenges in terms of production volume and cost, FinnBiotech chose to partner with companies in South Korea and India that would use FinnBiotech's manufacturing technology and ensuing expertise to build factories partially owned by FinnBiotech. In this way, FinnBiotech was able to extract value from its manufacturing innovation, even while overcoming the constraints of volume and cost.

What this suggests is that manufacturing innovation may play a larger role in modern biotechnology innovation than is often acknowledged. Being able to develop this competence internally because of lack of suitable partners was crucial for FinnBiotech. Moreover, even when manufacturing volumes and cost have required FinnBiotech to expand its production to lower-cost countries, this has been easier using already developed production technology and expertise. Furthermore, even while FinnBiotech has expanded production to Asia to increase volumes and drive down costs, it still maintains production in Finland in the same facility where its R&D is located. This co-location of R&D and production facilitated innovation in both products and production. This innovation was largely symbiotic as innovation in products would have had little value if it could not be adapted to mass manufacturing, and innovation in manufacturing needed to answer the demands of product innovation. Thus, although focus tends to be on product innovation in the

modern biotechnology sector, these results suggest that its link with production innovation may be stronger than suggested by the literature. Of course, manufacturing varies from one industrial branch of biotechnology application to another, but these results are intriguing.

The results indicate that FinnBiotech suffered much from the lack of a partner's marketing and distribution network. Lacking the resources to build its own marketing and distribution network, as well as suitable partners until very recently (December 2012) when it entered into a collaboration with an Indian medical equipment manufacturer, FinnBiotech was forced to rely on market-based relations for marketing and distribution. This clearly presented keen challenges, especially for information and knowledge acquisition. Nearly all of the interviewees mentioned multiple times the difficulties posed to innovation at FinnBiotech created by the dearth of information about end users, their behavior and experience of the tests, the true competitive positioning of the tests in markets around the world, and the pricing of the tests throughout the distribution network. This dearth of information was the result of marketing and distribution intermediaries hoarding information in order to gain power in contract negotiations with FinnBiotech.

The dearth of information about end users created problems for FinnBiotech's R&D because it lacked the kind of rich feedback from users that would have allowed it to develop its tests to best suit user behavior and experience. The dearth of information about prices at various points in the marketing and distribution network meant that FinnBiotech had a weaker position in contract negotiations, leaving it vulnerable to pressure exerted by the distribution intermediaries to keep its prices down. Indeed, the problems created by the lack of a marketing and distribution network were explicitly recognized by all of the management team members. Having a good large firm partner providing such a marketing and distribution network could have helped to alleviate this problem of information acquisition. Thus, it can be concluded that marketing and distribution are crucial for innovation in terms of acquiring information for creating innovation and for exploiting innovation, perhaps more so than has often been acknowledged.

Finally, venture capitalists as significant intermediaries were completely missing in FinnBiotech's development, which deviates from the literature based on experiences in the United States, but is in line with the literature documenting experiences elsewhere (Ward & Hodgson, 2006; Ward et al., 2005). At first, when FinnBiotech was just a fledgling startup, it did not have the credibility to raise venture capital internationally, and venture capitalists were lacking in Finland at the time. Later, when FinnBiotech

became more established, venture capitalists became interested in investing in the firm, but at that time FinnBiotech no longer needed them. While the lack of venture capital financing is often decried as a major limiting factor in the development of European small dedicated biotechnology firms (Ward & Hodgson, 2006; Ward et al., 2005), it seems that it is possible to develop a successful small dedicated biotechnology firm without venture capital financing. FinnBiotech did this by being able to generate income from the very beginning and by limiting R&D investments to what it could afford, supplemented to a modest extent by bank loans. Certainly, this did constrain FinnBiotech's growth, but nonetheless, it was possible.

Moreover, a somewhat speculative but interesting conclusion can be drawn which suggests that FinnBiotech was able to compensate for the important intermediary role usually played by venture capitalists: that is, bringing business expertise and business connections to complement the scientific expertise and scientific connections of small high-technology firms. This was because FinnBiotech's founders, although all with scientific backgrounds, came from both business and scientific organizations involved in the government-initiated science transfer and development project from which FinnBiotech acquired its initial scientific and technological basis. This initial combination of scientific, business, and entrepreneurial experience, together with the wide range of previous connections this experience provided, appears to have been highly significant for FinnBiotech's success. FinnBiotech was able to start with a knowledge base that spanned both scientific knowledge and knowledge of "complementary assets," together with a network of connections that provided access to information across this diversity of information domains. This suggests that it is the combination of expertise and connections that is crucial for providing the foundation for innovation. The specific model by which this is created may be less crucial. Hence, the absence of venture capitalists need not be a debilitating hindrance.

Analyses of interorganizational collaboration in biotechnology have led researchers to posit that the most crucial resource being shared in these collaborations is information, so that information acquisition is critical for innovation (Owen-Smith & Powell, 2004; Powell, 1998; Powell et al., 1996). Moreover, the knowledge necessary for innovation in modern biotechnology is posited to always have considerable tacit components, thus requiring personal interaction for its transmission (Senker, 1993, 1995). The findings at FinnBiotech were closely in line with what might be expected based on the literature: innovation at FinnBiotech depended on multiple sources of external information. Moreover, the findings were in line with what might be expected

based on arguments that all knowledge needed for innovation in modern biotechnology has significant tacit components, its transmission requiring personal interaction with the sources of the information. The narratives provide support for this conclusion.

In Narrative 1, the development of a celiac test innovation, the importance of personal contacts for successful information acquisition came through especially clearly. Comparing the two instances where FinnBiotech attempted to make the invention function in their own laboratory, a clear difference exists in the extent of direct personal contact by FinnBiotech's R&D employees with the developers of the invention. In the first instance, FinnBiotech had received documented information through the technology transfer office of the University of Tampere, where the scientists had developed the invention. FinnBiotech's R&D employees were also in direct contact with the scientists, but the extent of this was limited, and FinnBiotech's attempt to make the invention function in its own laboratory in Vantaa failed. However, the key turning point in the narrative came as a result of FinnBiotech's R&D employees significantly increasing the extent of their contact with the University of Tampere scientists. This made it possible for FinnBiotech's R&D Manager to obtain information directly from the scientists, revealing a misunderstanding that had led to an internal error at FinnBiotech's laboratory in Vantaa. The increased direct personal contact between FinnBiotech's R&D employees and the scientists from the University of Tampere made it possible to correct this error. Having overcome this hurdle, FinnBiotech was able to develop the invention into an innovation, which became the second most important product in FinnBiotech's sales. This narrative may be contrasted with Narrative 6 where, when FinnBiotech's R&D employees encountered a problem developing a new product in their laboratory, they were unable to contact the original creators of the invention to receive the necessary information to solve the problem. As a result, they were unable to proceed with development and the outcome was judged to be a failure.

A third narrative, Narrative 5, provides nuance to these two events. At first interpretation, it appears to suggest that while direct personal contact may be a critical condition for successful product innovation development in modern biotechnology, it is not a sufficient condition. This interpretation rests on the emphasis in the narrative provided by the R&D Manager that in this attempt to develop a product innovation consisting of a rapid test version of a laboratory test for celiac disease developed by an Italian company, there had been direct personal information sharing between FinnBiotech's R&D

employees and those of the Italian company in a manner that FinnBiotech's R&D Manager characterized as open, active, and frequent, with neither side holding information back. This perception gains support from the fact that FinnBiotech and the Italian company shared the goal of successfully developing this rapid test for celiac disease. Thus, each had the incentive to wish to ensure the other's success. However, it would seem that such direct personal information sharing was not sufficient for a successful production innovation. There is a small detail in this narrative which suggests that it does not deviate entirely from the conclusion about the importance of direct personal contact for sharing also the tacit components of information: while the information sharing took place openly in direct personal contact, most of this contact was not face-to-face but through digital communications.

This brings the discussion to the importance of local agglomeration of innovation activities in modern biotechnology. Here the findings deviate quite strongly from the existing literature, which argues that the need for tacit knowledge to be shared face-to-face leads to strong tendencies of local agglomeration of small dedicated biotechnology firms (Cooke, 2002a, 2002b). While the previous discussion indicates that direct personal contact is crucial for sharing the tacit components of information, and hence for successful innovation, most personal information sources for FinnBiotech's innovation were not local. Indeed, local information sources were crucial only at the time of FinnBiotech's founding. Ever since then, its information sources for innovation were global. Moreover, there is the added twist—that FinnBiotech's founding was enabled by international transfer of scientific knowledge.

FinnBiotech acquired information about science, product development, customers and markets, as well as quality, regulation, and patenting from around the globe. The only exception was information about production technology, but this was because FinnBiotech had been forced to develop its production technology in-house, so that it did not acquire much information externally. In short, FinnBiotech needed and sought information that was most relevant to its innovation, regardless of where this information was located in the world. Most of the information that proved to be relevant for innovation was abroad. This is in line with literature on information acquisition in by Swedish biotechnology firms (Dahlander & McKelvey, 2005; McKelvey et al., 2003; Waxell & Malmberg, 2007). This suggests that a small biotechnology company such as FinnBiotech, located in a small country like Finland, may be disadvantaged because it needs to go to the extra trouble of acquiring information internationally. If we wish to understand innovation in firms in these kinds of contexts, it is important to appreciate that the

information acquisition tactics they need to resort to are likely to require the extra effort of conducting these activities internationally.

However, an interesting observation from the results is that acquiring information, even that which could be classified as complex and high in tacit components, was possible to do internationally. As long as there was direct personal contact, and at least same face-to-face communication, it was possible to acquire information successfully for innovation, especially product innovation. Although much of this information was high in tacit components, its acquisition did not require permanent (or even long-term) co-location of the individuals communicating it. Permanent co-location of the individuals with the relevant information would have made such communication easier, as the individuals acquiring information at FinnBiotech needed to travel frequently in different parts of the world, spending much time and money on air travel. However, it was not a necessity, contrary to arguments (Tallman & Chacar, 2011).

The other argument put forth in much of the literature emphasizing the importance of co-location is that permanent physical co-location of individuals gives rise to social networks that develop over long periods of time and are difficult for outsiders to enter (Johanson & Vahlne, 2009; Owen-Smith & Powell, 2004; Powell, 1998; Powell et al., 2005). This did not appear to hold true for FinnBiotech, where social network connections were created to link distant individuals in order to exchange information. At international industry fairs, social network connections between individuals from various different countries were forged and maintained. Interviewees spoke of arranging meetings from one industry fair to another in order to explore new mutual interests and to foster existing business relationships. Although the concrete purpose of these meetings was to create sales from one company to another, nearly all of the interviewees emphasized the importance of meetings at industry fairs for the acquisition of information. Some of this was planned, some not. It would have been impossible to plan or contrive the chain of events described in Narrative 2. The individuals came together quite serendipitously.

Permanent co-location, argued in much of the literature to be necessary for the formation of the social networks that permit information acquisition (Owen-Smith & Powell, 2004; Powell, 1998; Powell et al., 2005), has not been necessary for FinnBiotech. It was not necessary for individuals to have a long shared past during which trust and understanding had been built up. Relevance appeared to outweigh convenience. It may have been easier to connect with individuals who were familiar and were physically co-located, but if they were not relevant for business or innovation purposes, this convenience

was of little value. This is not to say that individuals connected with each other completely randomly. The Russian man who came to visit FinnBiotech's office unannounced did so knowing about FinnBiotech: his sister had worked in the diagnostics industry in Finland and informed her brother about FinnBiotech. Certainly, FinnBiotech's Managing Director made a snap judgment to trust the Russian man with a batch of tests. At the same time, he could be seen taking a limited risk at first, his relationship with the Russian man building gradually as each found the other to be trustworthy and to share interests. Similarly, the creation of the connection between FinnBiotech's Managing Director and South Korean individuals through the Russian man was serendipitous, but there was a shared background between the South Koreans and the Russian man, all having worked at the National Institutes of Health in the United States. Furthermore, after the initial South Korean connections were made by FinnBiotech's Managing Director, the resulting connections in South Korea were based on family relationships.

Many of the new relationships that FinnBiotech was able to create at industry fairs were driven by its growing reputation in its industry, which helped to attract attention and trust. The social relationship building took place in a community of its own, that of the diagnostics industry, and even more specifically, that of the point-of-care and rapid test industry. This community was not physically co-located, but exhibited many of the social network dynamics posited to exist in physically co-located clusters, such as gradual relationship building over often long periods of time, reputation-based trust generated and communicated largely by word-of-mouth, and face-to-face communication at the industry fairs. Intriguingly, all this happened in a physically dispersed community rather than the local community emphasized in the literature.

These findings thus diverge from the consensus in the literature on some important points, notably the relative unimportance of university research, the greatest information acquisition challenges being related to customers and markets, and the important factor supporting information acquisition being shared experience in the international diagnostics industry. It is possible that the findings are the result of this company being a special case, but it is also possible that they relate to the sector in which this company is located, the biotechnology equipment and supplies sector. Indeed, prior evidence demonstrates that biotechnology innovation dynamics vary between industries (Senker, van Zwanenberg, Caloghirou, Zambarloukos, Kolisis, Enzing, et al., 2001). The available literature on innovation in biotechnology mainly focuses on the pharmaceuticals industry, and it is possible that the

biotechnology innovation dynamics described in this literature are peculiar to the pharmaceuticals industry. As the data in this study was gathered from a firm in the biotechnology equipment and supplies industry, it may be that where the results in this study diverge from the literature, this reflects different biotechnology innovation dynamics in industries other than pharmaceuticals. However, the question of whether these findings reflect a special case or innovation dynamics particular to the biotechnology equipment and supplies sector can only be answered by further research on information acquisition for innovation by small companies in other sectors.

5.2 REFLECTIONS ON INTERNATIONAL INFORMATION ACQUISITION

Four perspectives with which to viw information acquisition were identified in the international business literature. These were labeled as approaching information acquisition in international business primarily in terms of:

1) information transactions
2) experiential and network learning
3) tacit information transmission and conversion
4) social learning in communities and networks of practice

The first perspective focuses on difficulties affecting information transactions resulting primarily from information asymmetry and opportunism and amenable to resolution by internalizing transactions (Buckley & Casson, 1976, 1986; Hennart, 1977, 1982, 2003). The second perspective emphasizes the importance of experiential knowledge, distinguished from objective knowledge, and the consequent gradual nature of experiential learning (Johanson & Vahlne, 1977, 1990, 2009). The third perspective argues for the importance of tacit knowledge and postulates that its transmission requires shared codes provided by a community (Nonaka, 1994; Nonaka & Takeuchi, 1995), and asserts that multinational companies constitute such communities (Kogut & Zander, 1993). The fourth perspective proclaims that all knowledge has tacit components and is therefore embedded in local intra-organizational communities of practice and local interorganizational networks of practice, which the multinational company must tap into in order to acquire information internationally (Tallman & Chacar, 2011). The first, second, and

fourth perspectives resonated somewhat with the results, but none of them completely.

The first perspective, which emphasizes difficulties of information transactions (Buckley & Casson, 1976, 1986; Hennart, 1977, 1982, 2003) echoed with the results in that the information that was most challenging for FinnBiotech to acquire was information about end users and prices at various points on the distribution chain. None of this information could really be characterized as complex or as having significant tacit components. Instead, this information was difficult to acquire because FinnBiotech had to rely on market-based relationships in its marketing and distribution network, which resulted in each actor (i.e., firm in this discussion) aiming to optimize its own gain at the expense of others. As a result, each market actor hoarded information that could increase the power it wielded in contract negotiations with the other actors. Hence, the market actors could be seen as trying to bring about, and maintain, information asymmetry among themselves. Thus, while this economics-based perspective to understanding information in international business has somewhat fallen out of fashion, the results suggest that it can be an important tool to understanding information acquisition in international business.

The second perspective, which emphasizes the importance of experience and argues that it is gained only gradually (Johanson & Vahlne, 1977, 1990, 2009) echoed somewhat with the results. Continued experiential learning, for instance about ways to act in international industry fairs, provided a gradually improving basis for acquiring information necessary for innovation. However, the dichotomy posited between experiential and objective information in this perspective was problematic. While it is quite impossible to argue against the importance of experience, the way experiential information is conceptualized in this perspective did not readily lend itself to a logical interpretation of the results. Neither did the concept of relationship-specific information. FinnBiotech was juggling so many partners that it could not be said to have committed to learning deeply about any specific partners. Indeed, to do so might have been detrimental to innovation, as it is often noted in the innovation literature that a wide and diverse information base helps foster innovation.

The third perspective, which emphasizes the difficulties of transmitting tacit knowledge (Nonaka, 1994; Nonaka & Takeuchi, 1995) and maintains that the multinational corporation exists as a community of shared codes to do this (Kogut & Zander, 1993), appeared quite problematic when trying to use it to interpret the results. The most problematic aspect could be said to be its sharp,

even dichotomous distinction between explicit information and tacit knowledge, similar to the dichotomous distinction between objective knowledge and experiential knowledge in the second perspective. Certainly, some variations of the argument in this perspective assert that knowledge differs in the extent of its tacit components, rather than positing that explicit and tacit knowledge constitute two distinct and dichotomous knowledge types (Kogut & Zander, 1993). However, even while appreciating this subtlety, this theoretical perspective still did not resonate with the results. The literature holds that information that is highest in tacit components is the most difficult to transmit. This was not the case here. The information that was the most difficult to acquire involved end users and prices and much of it was quite simple and explicit. Moreover, it is argued in this perspective that information high in tacit components can be transmitted only in communities that share the same codes, rules, and routines, and that multinational companies are the pre-eminent international communities able to do this. However, it emerged in the results that shared codes, rules, and routines could be sustained in international communities beyond firms, such as the one maintained by international industry fairs in the international diagnostics industry.

The fourth perspective, which emphasizes joint participation in an activity as a way to learn architectural knowledge that helps the sharing of component knowledge (Tallman & Chacar, 2011), resonated with the identified facilitating factors in information acquisition in this study—similar work practices/activities and educational/professional backgrounds. However, this perspective emphasizes physical co-location. The results strongly deviated from this, as information acquisition was not local but global. Furthermore, the foremost community constructed by joint participation in an activity was the physically dispersed international community of the diagnostics industry. This international community of practice dominantly provided shared understandings and facilitated information acquisition.

5.3 FURTHER THOUGHTS FOR RESEARCH

There were important themes that emerged from the empirical study that could not be accommodated within the literature. These themes are reviewed here, noting points of convergence with other existing theoretical discussions that may be identified as not having been fully used in conjunction with the topic of information acquisition for innovation in international business. It is suggested that examining these themes in further research would be important

and intriguing, and that theoretical streams exist already which can be drawn upon in such research.

5.3.1 Importance of "Right Information"

Throughout the dissertation, the terms "information" and "knowledge" have been used in combination, sometimes roughly synonymously. This was a choice made on the basis of the literature review, in which both terms are used and are often not distinguished. The same partial confluence of terms could be noted in the results because of the difficulties posed by translating from Finnish, where only a single term exists for both "information" and "knowledge." However, it was clear from the results that information and knowledge need to be distinguished. The interviewees repeatedly talked about the importance of "right information" and about the criticality of processing it in a way that may be interpreted as referring to the processing of information in order to convert it into knowledge. In turn, it was crucial to be able to act on this knowledge, but action could only ensue on the basis of knowledge as processed information, not on information *per se*. Indeed, the interviewees were insistent that information in itself was not valuable—only "right information" was valuable, and even then, it needed to be processed into knowledge that provided a basis for actions.

The interviewees talked throughout the interviews about "right information," stating that information in itself was neither valuable nor difficult to acquire, but "right information" was. It was this "right information" that was valuable and which was experienced at times as challenging to acquire. The interviewees also defined, unprompted, this right information in very similar ways: as information that was necessary and relevant to their work activities and FinnBiotech in general, sufficiently focused and specific, and—this being particularly significant—reliable. The importance of reliability of information was emphasized as a key factor in what made information valuable. This was because, for a small firm like FinnBiotech, unreliable and incorrect information was highly dangerous, possibly leading to mistakes that could be fatal for a small firm.

The interviewees all emphasized a point that also came out indirectly in the interviews, that "right information" was only a small part of all information that is available. Indeed, the voluminous amounts of information available were often hindrances in the quest to acquire "right information," as this required expending considerable resources sifting through mountains of information. In the vernacular, one might describe "right information" as

being akin to a needle in a haystack. Thus, the ability to identify, select, and evaluate information in order to be able to consider it "right information" was critical. Interviewees made judgments concerning what could be considered "right information" by transposing reasoning processes from their scientific training. They checked information from several independent sources and evaluated the quality of the methods used in obtaining the conclusions. Such reasoning processes were applied to all types of information all the way through to market gossip.

It is intriguing that the distinction between information *per se*, and information that may be considered "right information" has not been made in the international business literature. The literature tends to consider information and knowledge as good and valuable *per se*. Thus, the concept of knowledge easily becomes excessively vague, readily applied to anything and everything. As Alvesson (2004) notes, discussion has often fallen into what he calls a "knowledge is just good" trap:

> Since everything can be seen as knowledge in one way or another, the term easily leads to rather vague and all-embracing statements. It is odd to read texts that avoid defining what knowledge actually refers to but still confidently claim that this unknown quality or ill-defined phenomenon accomplishes all sorts of good things. … Knowledge too easily leads to efforts to cover broad terrain. (Alvesson 2004: 229 - 230)

In some other bodies of literature, especially that dealing with competitive intelligence and innovation, the problem of abundance of external information for innovation has been noted (Macdonald, 2006). Here, the question has been raised of how an organization is able to find the information it needs from this abundance of external information. It is argued in this literature that what is "right information" is information that is found and assessed by an expert using his/her knowledge to find and assess bits of new information that can increase his/her knowledge. Only the expert is able to tell what information is new, relevant, valuable, and reliable.

The interviewees were able to carry out the critical functions of identifying "right information" from the excess of all information. They had the requisite expertise to be able to evaluate the information at hand. In other words, at one extreme, when they were dealing with scientific knowledge in their own field, they found it very easy to evaluate the profusion of information, select the necessary bits, evaluate them for relevance and

reliability, and combine them with other pieces of information. However, when the interviewees were faced with a new type of situation, such as that of the patenting dispute where the U.S. company was using patenting as a hostile competitive strategy, they were not able "sniff out" the "right information" they would have needed to expertly deal with this problem. They had no expertise in the area, no knowledge. Were such a situation to arise again, they would be better equipped to deal with it, as the Managing Director actually described this incident as an example of "very expensive learning."

5.3.2 Importance of Converting Information into Knowledge

Although the interviewees did not distinguish between information and knowledge, largely because of the constraints of the Finnish language in which the interviews were conducted, many of their descriptions of what they did with the "right information" could be interpreted as descriptions of converting information into knowledge. Having selected and evaluated information to draw the conclusion that it could be considered "right knowledge," the interviewees repeatedly described analyzing and interpreting this information as well as combining it with other information. These activities could be interpreted as the conversion of information into knowledge. Converting information into knowledge required similar types of expertise to those involved in finding "right information": using their expertise, the interviewees were able to analyze, interpret, and combine information into knowledge. Thus, the resources needed were specifically human capabilities—humans being active and using their minds and existing knowledge and skills to seek out, select, and evaluate "right information," then to analyze and interpret it for use, and combine it with other pieces of "right information." As the narratives pointed out, clues and ideas were actively sought and creatively combined in order to reach conclusions that would not have been available otherwise. The interviewees described asking for hints, or being alert to little snippets of information "falling out" accidentally in informal conversations; by being alert to these pieces of information and creatively combining them, they could construct findings.

Thus, to arrive at "right information" and knowledge involved activity throughout, from evaluating and interpreting available information, actively seeking new bits of information to complement existing information, and actively creating new knowledge from little bits and pieces. In other words, acquiring knowledge was not so much about straightforward sharing or not sharing of information between market participants, but about the active use

of the human mind to arrive first at "right information" and to then convert it into knowledge. Through mental activity, individuals could surmise much more than was directly communicated, creating new knowledge rather than passively expecting to receive it as a ready-made entity. Knowing where to search for information, being able to recognize what was useful, and being able to analyze, evaluate, interpret, and combine it was vital.

It is beyond the scope of this dissertation to delve into the complex discussions of what knowledge is. However, it is noted that the classical philosophical definition of knowledge as justified true belief could be seen to fit the results. Nonaka et al. are perhaps the most influential detractors from the classical definition of knowledge as justified true belief. Although in most of the publications, Nonaka et al. claim to have adopted the definition of knowledge as justified true belief, they do state that they have actually modified this definition considerably, mostly considering knowledge to be personal belief and emphasizing its justification, largely dismissing the need for truthfulness (Nonaka & Takeuchi, 1995). This is said to be because the dynamism of the business environment means that individuals acting in this context do not have the luxury of arriving at justified true belief, needing to use justified belief instead in order to function in their fast-paced world. However, the results here point to the opposite: individuals acting in this business world could not act on justified belief. They needed to ascertain that these beliefs were also true. In other words, as FinnBiotech's Managing Director emphasized, acting on knowledge which turned out to be incorrect could lead to mistakes that might be fatal to such a small company. A large company is much more likely to have the resources to be able to absorb mistakes without foundering. Nonetheless, one can speculate that incorrect knowledge would be harmful also to larger companies. The argument is intriguing: knowledge must be true if it is to form a sound basis for action.

The claim attached to the communities-of-practice concept that knowledge inheres in social relations rather than in individual minds insists that the classical definition of knowledge as justified true belief is outmoded. However, the results here accommodate both a definition of knowledge as justified true belief and the importance of social relations for knowledge. Moreover, this argument is also made in contemporary philosophy: Longino (2002) argues that social relations and individual human reason are not in opposition. Moreover, the definition of knowledge as justified true belief is often dismissed on the grounds that it leads to a positivist philosophy. It does not. This classical philosophical definition of knowledge is commensurate with nearly all strands of philosophy, as different streams simply define the

conditions under which belief is considered to be justified and true differently (Moser & vander Nat, 2003). Furthermore, claiming that it is important to pay attention to converting information into knowledge does not necessarily mean the adoption of an information-processing approach (Crowther-Heyck, 2005; Richards, 2003), contrary to arguments by Nonaka et al. (Nonaka & Takeuchi, 1995; Nonaka, Umemoto, & Senoo, 1996). Instead, this claim logically leads to examinations of how individuals determine what constitutes truth and justification in different situations, in other words, how knowledge is manufactured in various contexts. This notion is similar to Knorr-Cetina's work on epistemic cultures (Knorr-Cetina, 1999).

The conclusion here is that it is important to distinguish between information and knowledge, and here the classical definition of knowledge as justified true belief helps shed light on what needs to be done to information in order to arrive at considering it knowledge: it needs to be judged to be justifiably true. This is important for individuals making decisions in a small firm. Were they to act solely on justified beliefs, especially of the kind Nonaka describes as justified by prior strategic decisions, this would constrain their ability to innovate. Moreover, theoretical arguments can be found in contemporary philosophy that provide support for the conclusion that highlighting the definition of knowledge as justified true belief need to neither exclude social aspects of knowing nor lead to positivist philosophy. Indeed, it can be claimed that emphasizing the importance of justification and truth, arrived at through individual interpretation, is in accordance with Polanyi's original argument that knowledge can never be entirely separated from individuals (Polanyi, [1966] 1983). Hence, it becomes questionable whether knowledge can ever be acquired, or whether an individual always acquires information that can be converted into knowledge only through that individual's active interpretation.

5.3.3 Importance of Ability to Act on Knowledge

Information, even if it is "right information" and is processed into knowledge, is not valuable if it cannot be used. Hence, it is emphasized in the results of the present study that knowledge needed to be very specific and close to actual activities: no matter how well selected, evaluated, analyzed, interpreted, and combined, if the knowledge could not be used it was of no value. However, the challenge of using knowledge was oriented more towards the capabilities of the individuals using it than the content and characteristics of knowledge. In other words, here again the individuals needed to have the expertise required to be

able to use knowledge in actual activities. This is in line with sociology of knowledge literature. For example, in discussing economically and societally productive knowledge, Stehr (2001) argues that the utility of knowledge does not intrinsically reside in knowledge: rather, it is a capacity for action that needs to be used for knowledge to be productive.

5.3.4 International Communities and Networks of Practice

The main community that facilitated information acquisition in international business was the diagnostics industry, largely maintained by international industry fairs. This contrasts with arguments in international business studies of the pre-eminence of nations, multinational corporations, and local communities and networks of practice as providing the primary social institutions within which information can be communicated. This study finds that information for innovation could be acquired successfully across national borders, organizational boundaries, and over long distances as long as there was direct personal contact and some face-to-face communication. Rather than shared nationality, shared organizational membership, or permanent physical co-location, what enabled information acquisition, and the construction of social networks to help ease access, was shared educational background, shared industry experience, and shared goals and interests.

None of the theoretical perspectives in the literature review could help to interpret this existence of an international, inter-organizational industry community that was the pre-eminent facilitator of international information acquisition for innovation. However, these results are in accordance with literature within the so-called practice-theoretic perspective (Schatzki, 2002; Schatzki, Knorr-Cetina, & von Savigny, 2001). A core argument in this literature is that knowledge always has tacit components and is, therefore, always embedded in, and constituted by, socio-cultural practices where knowing is inherently connected with doing (Gherardi, 2000; Gherardi & Nicolini, 2001, 2005; Nicolini, Gherardi, & Yanow, 2003). This is the same core argument as in the perspective in international business studies which approaches international information acquisition as social learning in communities and networks of practice (Tallman & Chacar, 2011). However, as communities-of-practice theorizing (Brown & Duguid, [1991] 2000; Cox, 2005; Kimble, 2006) has inspired this perspective, it emphasizes physical co-location of these communities and networks of practice. However, some practice-based knowledge researchers specifically argue that groups can

sustain common knowledge practices even without physical co-location (Yanow, 2003).

Therefore, it is possible to view the existence of the international diagnostics industry through this theoretical lens, classifying it as a conglomeration of international—as opposed to local—communities and networks of practice, where practices are defined as structured human traditions for interaction around specific tasks and goals (Hedegaard, Chaiklin, & Jensen, 1999). Applying this to the results, these human traditions for interaction could be seen to generate an international diagnostics industry community around the shared tasks and goals of developing, selling, and using diagnostic tests and other equipment and services related to them. Acknowledging that the notion of practice as an analytical tool is theoretically unsaturated (Engeström & Miettinen, 1999; Hedegaard et al., 1999) provides further support that it is possible to consider practices to be constituted internationally as well as locally. In other words, the notion of practice is not exclusive tied to the concept of communities of practice with its emphasis on physical co-location. Actor-network theory (Latour, 2005) and activity theory (Chaiklin, Hedegaard, & Jensen, 1999; Engeström, Miettinen, & Punamäki, 1999; Hedegaard et al., 1999; Wertsch, 1985) within this perspective accord with this conclusion drawn from the results, as they both emphasize the role of intermediaries in practices. These intermediaries range from ideas to documents to physical tools, and they may be seen to enable the construction and maintenance of an international community, such as the diagnostics industry community, which is physically distributed, whose members are restricted to intermittent face-to-face contact, and hail from different national cultures and organizations.

This interpretation can be taken a step further when extending it to how the dynamics of the different information domains are examined. It appeared in the results that each of the information domains—revolving around the subjects of science, product development, production and production equipment, markets and customers, and quality, regulation, and patenting—had its own dynamics. If each of these domains is seen as constituted by practices in the actor-network and activity theoretic senses, they can be seen as structured human traditions for interaction around specific tasks and goals that rely on the use of intermediaries (Chaiklin et al., 1999; Engeström et al., 1999; Hedegaard et al., 1999; Latour, 2005). Viewing them in this way makes it possible to see that the expertise that was emphasized as making it possible to acquire "right information," convert it into knowledge, and act upon it is somewhat different in each of these information domains.

Indeed, the more knowledgeable and experienced the interviewees at FinnBiotech were about each of these information domains, the better they were able to navigate within its structured human traditions in order to acquire information successfully. By contrast, when they were inexperienced in a certain information domain, such as the use of patenting as an aggressive strategic competition tactic, they were not able to act in ways that could bring about such success. The greatest innovation success could come about when the interviewees had knowledge and expertise across all of the necessary information domains, and were able to acquire the necessary "right information" in each domain, convert it into knowledge, and act upon it to develop and exploit innovations internationally.

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