1-1-2010

An Exploration Of The Impact Of Organizational Culture On Innovation Performance In The Canadian Biotechnology Industry

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AN EXPLORATION OF THE IMPACT OF ORGANIZATIONAL CULTURE ON INNOVATION PERFORMANCE IN THE CANADIAN BIOTECHNOLOGY INDUSTRY

by

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BSc, Simon Fraser University, August, 1989

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A thesis

Presented to Ryerson University

In partial fulfillment of

the requirements for the degree of

Master of Management Science (MMSc)

in the program of

Management of Technology and Innovation

Toronto, Ontario, Canada, 2010

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Abstract

An Exploration of the Impact of Organizational Culture on Innovation Performance in the Canadian Biotechnology Industry

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Research addressing innovation performance in the Canadian biotech industry has primarily addressed financial metrics and not the influence of organizational culture. The lack of research on biotech organizations in terms of culture presented a "gap" in the research. An innovation performance model was developed based on the existing literature and the theorized linkages between constructs. The key addition to the conceptual model was the construct of organizational culture. The Competing Values Framework of Cameron and Quinn (1999) was the theoretical framework selected as the lens through which to explore the impact of culture on innovation performance, defined in terms of aggregate organizational patent output. Overall, based on the results of this research, the dominant culture for Canadian biotech firms is an adhocracy culture but a market culture generated greater innovation performance. Although, several constructs in the research model reached significance, organizational culture had a weak association with innovation performance.

Acknowledgements

I express my sincere gratitude to Ryerson University and the faculty that have assisted me during the program over the last two years. I am extremely grateful to my supervisor, Dr. Dave Valliere, who has guided me in the completion of this research initiative.

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1.0 Introduction

1.1 <u>Background</u>:

The Canadian biotechnology industry is a dynamic and diverse industry and its contribution to the economy continues to grow in importance. Until recently, Canada had the second highest number of biotech companies in the world next to the United States however; in 2008 Canada dropped to third behind Germany (van Beuzekom and Arundel, 2009; Ernst and Young, 2009). Nevertheless, on a per capita basis, Canada has more biotechnology firms than any other country in the world (BioTalent, 2008). In 2005 the industry generated revenues close to $4.2 billion with over 13,400 employees (Statistics Canada, 2007). The OECD definition of biotechnology will be used in this research initiative. However, recently, discussion has focused on the bio-based economy and economy that uses biological tools and products for treatments, agriculture, the environment, diagnostics, chemical processes and energy. Canada's 2007 bio-based economy, measured in GDP, was valued at approximately $78.3 billion, equivalent to 6.40% of Canada's national GDP and larger than the automotive industry (Pellerin and Taylor, 2008). If the current growth rate continues, the bio-based industry will exceed oil & gas by 2011 (Pellerin and Taylor, 2008). Although Canada only contributes 1.8% to the global economy, in terms of biotechnology, Canada generates 4% of global biotech revenue (BIOTECanada, 2009). In addition, it appears Canada has significant room for growth when compared to the US biotech industry which is 60% more developed than Canada, at 8.45% of total GDP versus Canada's 6.4% (BIOTECanada, 2009; Pellerin and Taylor, 2008).

The innovative biotechnology industry experienced a 9% increase from 2003 to 2005 in revenues and number of companies (Industry Canada, 2008). Nevertheless, growth levels have declined since 2001 and 2003, where a 31% rise in firm growth was achieved (Statistics Canada, 2007). The recent Canadian Blueprint from BIOTECanada identified attracting investment for commercialization as one of the biggest challenges facing the industry (BIOTECanada, 2009). In 2009, many biotech firms faced possible failure (burn out), as 25% of Canadian biotech firms were out of money and potentially 50% of firms were anticipated to be out of cash by the end of 2009 (Public Policy Forum, 2009). The global recession has been very hard on the biotechnology industry, and access to venture capital has dropped significantly, creating a reduction in R&D, employment losses and firm contractions.

Despite the recent challenges Canadian biotech firms continue to move forward with different business models and strategies to increase their value and the assets they are developing. It is clear that not all firms will survive and profitability may be years away for others but many firms will reward their investors for the risk they have taken and the patience they have shown. In an industry that is experiencing a cash crunch a key challenge for investors will be identifying biotech firms that will be successful.

Over the next three to five years there is anticipated to be a significant human resources challenge facing biotech firms due to a lack of skilled and experienced workers and the inability to recruit and retain employees (BioTalent, 2008). Over 34% of biotechnology companies are dealing with skill shortages ranging from a lack of knowledge-based skills to insufficient business, management and leadership skills (BioTalent, 2008).

Currently, Canada continues to outperform Europe in terms of innovation performance, based on patents per capita (Mohnen and Therrien, 2002). In addition, the Canadian biotech industry's revenues exceed the amount spent on R&D, indicating that some firms are able to convert innovation into a revenue stream (Statistics Canada, 2007). However, with a decline in industry growth and a third of biotech companies experiencing "skills" shortages, it will be a challenge to maintain innovation performance that keeps revenues growing and, specifically, revenue growth in excess of R&D investment.

Biotechnology, by its basic nature, is based on innovation (Alegre *et al*., 2009; Hunter, 2002; Hall and Bagchi-Sen, 2002; Renko *et al.,* 2009) as organizations compete to commercialize the newest drug, medical device, diagnostic test or animal vaccine before another competitor enters the marketplace. Innovation and specifically innovation performance in the Canadian biotechnology landscape is a recent area of research but, the focus has mostly been on financial metrics (level of investment in biotechnology, research and development (R&D) expenditure, revenue and profitability), or what are typically referred to as hard assets (Traore, 2004).

Organizational design, leadership roles, management skills and culture are key issues in terms of the generation of new technology, since these aspects of organizations have a significant impact on a firm's ability to innovate (Teece, 1996). The work done by Gittelman (2006) found that organizational capabilities affect innovation outcomes (patent citations). Furthermore, Gittelman found that entrepreneurial firms had superior capabilities to innovate in the biotechnology sector versus larger organizational designs (Gittelman, 2006). The firm's intangible assets need to be taken into account in assessing constructs that influence innovation performance. Knowledge-management related activities, as well as creativity and ideas management, are important variables to consider in the ability of a firm to manage innovation processes (Prajogo and Ahmed, 2006). High absorptive capacity is an important managerial capability and organizational innovation is at least as important as technological innovation (Volberda and van den Bosch, 2005). The knowledge assets, competencies and capabilities of firms impact productive capacity and, for biotechnology firms, there needs to be growth in intellectual capital if innovation performance is to improve (Kianto, 2008; Terziovski and Morgan, 2006). A firm with well-developed knowledge will have high absorptive capacity and will be able to act on new information or ideas in a specific field (Deeds, 2001). Organizational forms will influence how a firm processes knowledge as well as the potential for knowledge absorption (Van den Bosch *et al.,* 1999). Furthermore, organizational knowledge environments develop with firm structures and capabilities that are suitable for absorbing knowledge (Van den Bosch *et al*., 1999). An organization's absorptive capacity will depend on the cumulative capacity of the firm's members and, as such, will increase based on the prior investment in the development of individual absorptive capacity (Cohen and Levinthal, 1990).

Organizational structures (networks and alliances) as well as organizational characteristics (firm size and age) have been investigated in a number of studies, Bagchi-Sen and Scully (2004); Baum *et al.,* (2000); Hall and Bagchi-Sen, (2002); Hall and Bagchi-Sen, (2007); Hunter, (2002); Gittelman (2006); Powell *et al*., (1996); Sabourin and Pinsonneault (1997); Traore (2006); Terziovski and Morgan (2006); and van Moorsel *et al.,* (2007). However, despite the significant size and economic importance of the Canadian biotech sector, there is very little information about the influence of organizational aspects, such as culture, on innovation performance.

The working definition of organizational culture in this research is "the shared core values, ideas, underlying assumptions and expectations that play a key role throughout the firm". Culture is the "glue" that keeps organizations together, the clear set of values to manage existing and new situations, providing the firm with both stability and adaptability. Organizational culture includes firm values, behaviors, norms, language and symbols, leadership styles, atmosphere, processes, routines and the criteria of success that makes the firm distinct (Cameron and Quinn 1999; Morcillo *et al*., 2007). Culture is the informal structure of an organization, the pattern of beliefs and expectations shared by individuals in the firm (Teece, 1996).

Firm culture is a critical factor in the long-term effectiveness, performance and financial success of organizations (Cameron and Quinn, 1999). The behavior of individuals and groups within the firm is shaped by the organizational culture and if a firm's culture and strategy do not align it will be very difficult to implement strategies that involve innovation (Teece, 1996). Organizations are successful when there is an ideal relationship between culture and innovation, and in some situations a firm's culture may not provide an environment favorable to the acceptance of innovation (Morcillo *et al*., 2007). It has been theorized that organizational culture is one of the most important barriers in a firm's ability to leverage new knowledge and implement technical innovation (Helfrich *et al*., 2007). Culture, within the organization can be explored at a global or individual level.

Recently, a public policy forum that discussed the future of the bio-based economy in Canada identified the most significant challenge to be a "culture of complacency" in terms of entrepreneurship and innovation (Public Policy Forum, 2009). Success in biotech requires a culture of innovation, risk-taking and willingness to function in an entrepreneurial environment (Vanderbyl and Kobelak, 2007). Innovation is considered an endogenous process as organizational choices affect process flows, the utilization of resources, employee interactions and ultimately outputs - innovative products or processes (Wu *et al.*, 2007). Consequently, the right culture is not just an important asset to assist in technological development it appears to be a requirement (Teece, 1996).

As Canadian society continues its transformation to a knowledge based economy, the importance of industries such as biotechnology will continue to increase. It is projected that the social and environmental impact of biotechnology in this century will be more significant than the impact that IT had in the last century (BIOTECanada, 2009). Considering the growing importance of biotechnology globally and also to the Canadian economy, research that provides insight into innovation performance in Canadian biotechnology firms is important to conduct.

1.2 **Research Perspective and Paradigm**:

The fundamental question of this research is; does organizational culture have an impact on the innovation performance of Canadian biotechnology organizations? In addition, what cultural typologies (i.e. types of organizational culture defined by a theoretical framework) have the most benefit on innovation performance?

The research question is situated within the area of organizational science and innovation. The epistemological orientation of this research falls under the functionalist paradigm. The functionalist approach assumes that the world is composed of relationships that can be identified, studied and measured through natural science approaches and, as a result, models are often applied as vehicles of understanding (Burrell and Morgan, 1979). The focus is problem based, in search of practical solutions and placing an understanding on order and the regulation of social affairs (Burrell and Morgan, 1979). Consequently, this research initiative will be viewed from an objective perspective, which is seeking a rational explanation of social affairs (Burrell and Morgan, 1979).

1.3 **Research Goals**:

Considering the importance of biotechnology and the challenges facing the industry, it is useful to examine some of the under-researched factors that may influence innovation performance. Research addressing innovation performance in the Canadian biotech industry has largely focused on financial metrics and not the influence of organizational culture. The lack of research on biotech organizations, specifically in terms of culture, represents a “gap” in the research and provides a compelling area to investigate.

The goal of this research is to better understand the impact of organizational culture on innovation performance in the Canadian biotechnology industry. The theoretical goal is to apply a deductive research method to develop and test an integrated framework that predicts innovation performance in the Canadian biotech industry. From a pragmatic perspective, information on how culture impacts innovation performance can assist managers in designing organizations that can maximize a firm's innovative potential. The fundamental conjecture of this research is that the phenomenon of organizational culture has an impact on the innovation performance of Canadian biotechnology organizations.

1.4 Structure of the Thesis:

This paper is structured in chapters. Chapter 2 provides a detailed literature review of innovation performance in biotechnology, organizational research in biotechnology and organizational culture. Chapter 3 outlines the theoretical framework, including the research model, the Competing Values Framework and hypotheses. Chapter 4 details the empirical test used in the research, with information on the operationalization of variables and research methods. Chapter 5 outlines the data analysis with details covering the statistical tests and findings. Chapter 6 provides a discussion of the research findings, limitations and provides suggestions for future research initiatives. Chapter 7 concludes by reviewing the research goals and implications of the research. The appendices provide in-depth details on the survey materials.

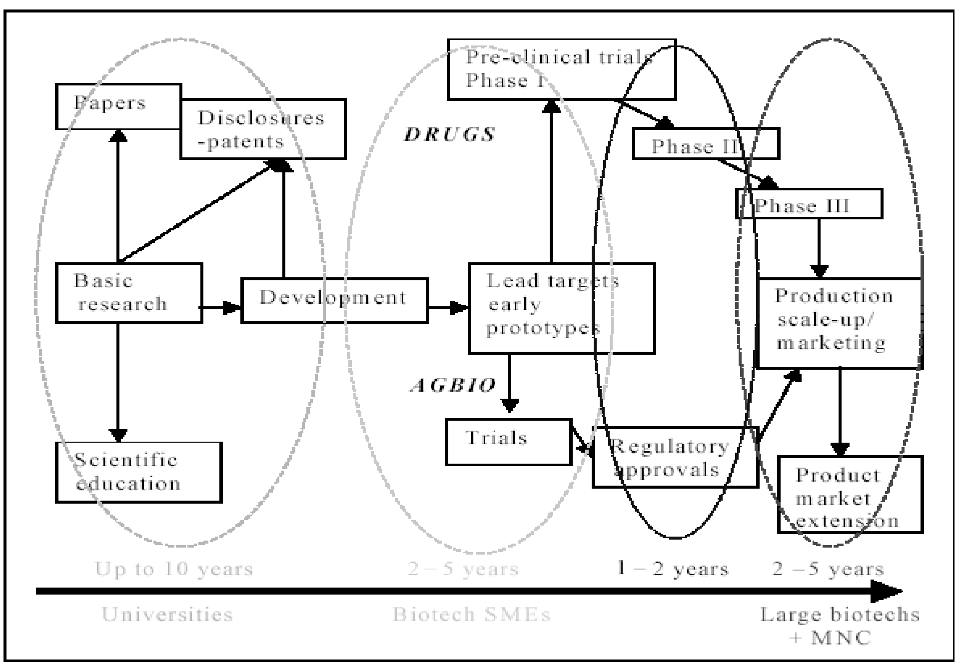
2.0 Literature Review

The literature review is divided into three sections: innovation performance in biotechnology, organizational research in biotechnology and organizational culture.

2.1 Innovation Performance in Biotechnology:

The biotechnology industry comprises many sectors, including agriculture, environment and human health. Close to 60% (303 out of 532 firms) of the innovative biotech firms in Canada are involved in human health (Statistics Canada, 2008). The development and commercialization process for many biotech products is outlined in the figure below developed by Sparling and Vitale (2003).

Figure 1: Biotechnology Development and Commercialization



Source: Sparling and Vitale, 2003.

Commercialization for human products runs from basic research (drug discovery) and pre-clinical assessment, through a phased clinical development sequence (i.e. Phase I, II & III) that assesses dosing, safety and efficacy. Once the pivotal trials are complete, usually Phase III trials, a regulatory submission is made to various governments (e.g., US FDA) to obtain marketing approval. The process for agricultural products (AgroBio) is more compressed and faster. However, before the commercialization process begins the firm will have already invested several years of basic research in order to generate innovative outputs in the form of intellectual property (patents). The drug discovery process requires patience and, as a result, significant funding, as it can take between 12 to15 years from discovery to product introduction.

The measurement of innovation has become a key issue (Alegre *et al.*, 2009) and it is often defined in terms of patenting rates, influenced by both macroeconomic and microeconomic variables (Mohnen and Therrien, 2002). Macroeconomic variables that influence innovation include the overall knowledge inventory (patents), human resources dedicated to innovation, government institutions and/or policies, public and private R&D funding, linkages (networks) and industrial clusters (Mohnen and Therrien, 2002). Nevertheless, it is ultimately the individual organization that performs the innovation leading to the commercialization of ideas. Consequently, organizations must develop internal processes to foster innovation and grow the firm's capabilities in order to generate new products and processes (Mohnen and Therrien, 2002). Microeconomic, or firm, determinants of innovation include size, industrial sector, proximity to the knowledge base (clusters), competition and internal firm decision capabilities that are linked to innovation (i.e. R&D activity, employee skill sets and cooperation) (Mohnen and Therrien, 2002). At the firm level, internal organizational decisions including human resources management systems can be beneficial to innovation (Laursen and Foss, 2003).

Innovation performance is not clearly defined in the literature, as the definition and operationalization of the term changes from one research initiative to another. For instance, innovation performance is defined as; *"the process of creating and developing new products and services through collaborative team processes and mechanisms that utilize and empower the skills and knowledge of people"* (Terziovski and Morgan, 2006, p. 545). Terziovski and Morgan used numerous innovation performance measures to assess innovation performance, including financial, operational, innovation and industry growth measures. In the work done by Prajogo and Ahmed (2006) innovation performance was never precisely defined, but was operationalized in terms of product innovation performance and process innovation performance, using a Likert scale instrument to capture a range of attitudes on the construct. Baum *et al.* (2000) measured innovation performance in startups' patenting and R&D spending growth. Traore (2006) defined firm innovative performance as the number of patents. Innovation performance was not clearly defined by Hall and Bagchi-Sen (2002) yet they viewed innovation performance as a relationship between R&D intensity, innovation measures and business performance. In subsequent work by Hall and Bagchi-Sen (2007), the measures of innovation performance included research-based innovation measures and production-based innovation measures. Omta *et al.* (1994) used both the number of patents and length of development (years) as measures of innovation performance. The recent work by Kang and Lee measured innovation performance in Korean biotech firms in terms of absolute patent counts (Kang and Lee, 2008). Alegre *et al.* (2009) operationalized innovation performance with a measurement scale combining the dimensions of efficiency and efficacy. Overall, one of the consistent themes in the literature is the use of patents as a measure of innovation.

Patents can be viewed as an output of the innovation process and can be easily measured. Patents indicate innovative capacity and have been used as a measure, as well as a driver, of a firm's innovation (van Moorsel *et al*., 2007; George *et al*., 2001). Patents are also a valuable measure of a firm's competencies (personal, social and/or organizational skills) and the firm's ability to produce results from internal resources such as R&D and personnel (Niosi and Bas, 2001). Patents are used as key indicators of innovation as they show technological progress in marketable assets that may become a future source of firm revenue (George *et al*., 2002; Zahra, 1996). Using patents to measure innovation provides a closer link between the recording and timing of the invention and, as such, patents represent not only an important measure of innovative output but are a validated measure of technological novelty (Rothaermel and Hess, 2007). Overall, patents have been identified as a quantitative nonmonetary measure of innovation performance that assesses the firm's technical unit (R&D) outputs (Cordero, 1989). A firm that patents heavily can be seen as building innovation capabilities in a new technological area (Renko *et al.,* 2009; Rothaermel and Hess, 2007). Consequently, although there are different metrics that can be applied to measure innovation performance based on how the variable is defined, the working definition of innovation performance for this research is the "process of creating and developing new products and processes measured through patents (applications and approvals)".

Innovation performance as an output can be operationalized through innovation measures such as domestic/international patent applications and domestic/international patent approvals (Bagchi-Sen and Scully 2004; Hall and Bagchi-Sen, 2002; Hall and Bagchi-Sen, 2007, van Moorsel *et al*., 2007). Patents are and output of the innovation process. Patents have been used as surrogate markers for innovation as they represent an intermediate output of the innovation process and are an excellent indicator of overall technological strength and the ability to use resources to produce valuable results (Narin *et al*., 1987; Niosi and Bas, 2001). Patents generated by a biotechnology firm reflect a degree of innovative capacity (van Moorsel *et al*., 2007). Intellectual property (IP), achieved through patent approval provides a firm with a significant benefit as it allows the firm to make a technological claim on a potentially innovative product or process (Baum *et al*., 2000). International patent applications and approvals should be included as a measure of innovation performance as biotech firms often file in the U.S. first to obtain a year of protection before filing in Canada and other international markets (Baum *et al*., 2000). In addition, the US is the largest market in the world for biotechnology and, as such, firms will file first in the US before applying for a patent in another nation (Rothaermel and Hess, 2007). Patents are generally filed well in advance of a process or product's introduction to the market and regardless of whether or not the innovation reaches the market, patents serve as a reliable measure of innovation (Hall and Bagchi-Sen, 2002).

The basic nature of biotechnology leads to a time lag between patent approval and market entry for innovations due to regulatory requirements, development gates and financial hurdles. Consistent with research performed in the Canadian biotechnology industry (Hall and Bagchi-Sen, 2002 and Hall and Bagchi-Sen, 2007) patent applications/approvals filed within the past five years will provide the time period for recording patents. The five-year time period is selected so that the overall patent count is not under estimated due to a time lag between patent applications and approvals. In the research performed by Baum *et al.* (2000), over 90% of the patents applied for were granted within 41 months of application for Canadian biotech firms. International patents applied for will be defined as, patents filed under the international patent law treaty, the Patent Cooperation Treaty (PCT). International patents that are approved (granted), are done by each regional or national authority. The European Union is an example of a regional authority.

Phenomena outside of traditional financial metrics are important to consider in terms of their influence on innovation performance. Table 1 outlines key research that has been completed in the biotechnology industry in regards to innovation performance.

Table 1: Innovation Performance Research in the Biotechnology Landscape

Author(s)	Focus of the study	Method of data collection	Method of data analysis	Findings
Alegre *et al.* (2009)	Innovation performance; French Biotechnology Industry	Survey (Questionnaire)	Structural equation modeling **Innovation Measures:** Innovation measurement scale comprising dimensions of efficiency and efficacy. A construct generated from a 12 item questionnaire	The research generated evidence that R&D resources improve innovation performance and organizational growth The phenomenon of entrepreneurship may be affecting R&D and, as a result, could impact innovation performance and organizational growth. Future research should address entrepreneurship
Bagchi-Sen and Scully (2004)	Innovation performance; An empirical study of the national system of innovation for the biotechnology industry in Canada	Survey (Questionnaire)	Descriptive data **Innovation Measures:** Patent approvals (domestic and international), patents that include external collaborators, new products and new processes	The industry needs to differentiate between high R&D intensity firms (therapeutics) and low R&D intensity firms (agriculture) as their needs are different High R&D intensity firms are more research focused and low R&D intensity firms are more process and product focused
Baum *et al.* (2000)	Innovation performance; Biotech alliance networks and their impact on innovative performance in Canadian biotechnology	Life histories – Archival data	Log-linear growth model & the Poisson regression model for count data (patents) **Innovation Measures:** Five dimensions (revenue, R&D	Innovative performance (patenting and R&D spending growth) was strongly impacted by the alliance networks of biotech startups Alliance networks form a centre of

			spending, non-R&D employees, R&D employees and patents granted)	innovation for high tech industries (biotech)
Gittelman (2006)	Innovation performance; Comparing innovation performance in the US & France	Archival Data (Derwent Biotechnology Abstracts)	Negative Binomial Models **Innovation Measures:** Patent citations	Entrepreneurial biotech firms were associated with high performing innovation (patent citations) in comparison to large established firms
Hall & Bagchi-Sen (2001)	Innovation performance; An analysis of R&D, innovation and business performance in US biotech	Survey (Questionnaire)	Chi-square statistics, t-values & measurement development (Likert scale) **Innovation Measures:** Patent applications & approvals; and new as well as redesigned product & process introductions	R&D intensive firms generated higher levels of patents R&D intensive firms were successful in obtaining contract revenue through licensing agreements
Hall & Bagchi-Sen (2002)	Innovation performance; Relationship between R&D Intensity, innovation measures and business performance in the Canadian biotechnology industry	Survey (Questionnaire)	Chi-square statistics, Spearman's non-parametric correlation statistics & measurement development (Likert scale) **Innovation Measures:** Patent applications & approvals; and new as well as redesigned product & process introductions	Absorptive capacity correlated with patent output New product introductions are significantly associated with business performance (i.e. total revenue growth, product sales growth, growth in exports and pretax profit growth)
Hall & Bagchi-Sen (2007)	Innovation performance; Factors that affect innovation strategies and performance (R&D Intensity) in the US	Survey (Questionnaire)	Chi-square statistics, Spearman's non-parametric correlation statistics & measurement development	Innovation performance was a result of well developed strategy and firm-level characteristics (e.g., absorptive capacity)

	biotechnology industry		**Innovation Measures:** Patent applications & approvals; and new as well as redesigned product & process introductions	Absorptive capacity was positively correlated with the number of domestic and international patent applications and approvals
Kang and Lee (2008)	Innovation performance; Innovation performance of Korean biotech firms	Survey (Questionnaire)	Poisson regression model **Innovation Measures:** Aggregate number of Patents (product and/or process innovations)	Number of R&D employees, CEO characteristics, absorptive capacity, government support and international collaborations were positively correlated with patent output
Marsh and Oxley (2005)	Innovation performance; Modeling innovative activity (output) in the New Zealand biotech sector	Survey (Questionnaire)	Poisson regression model **Innovative Measures:** Number of new products and/or processes, number of patents applied for	Smaller enterprises (measured in terms of biotech workers or biotech expenditure) had higher innovation rates International and not domestic biotech alliances had a positive effect on innovative output (biotech patents; and products and processes)
Omta *et al.* (1994)	Innovation performance; Innovation and industrial performance in European pharmaceutical R&D	Survey (Questionnaire)	Multi-variate analyses **Innovative Measures:** Two measure of innovation performance including; number of patents and length of development (years)	Larger firms in comparison to smaller firms (based on sales volume), submitted more patents in absolute number and also in comparison to their R&D investment The drug development process was significantly shorter for larger firms

				Human factors, flexible procedures and networking were crucial in R&D and pharmaceutical innovation
Renko *et al.* (2009)	Innovation performance; An analysis of the effect of market & entrepreneurial orientation; and technological capability on product innovativeness in Scandinavian & US Biotech start-ups	Interviews	Multiple Linear Regression and t-tests **Innovative Measures:** A composite measure (sum) of; new product introductions, NPD projects started and end products developed by firm inventions	The research identified a significant link between technological capability (i.e. patent numbers and R&D expenses in relation to total firm expenses) and innovativeness (i.e. generation of new products). In addition, patent count was positively associated with the level of capital invested in the biotech organization Neither market nor entrepreneurial orientation were related to product innovativeness
Terziovski and Morgan (2006)	Innovation performance; Practices and strategies that are critical to successful commercialization and impact innovation performance in Australian biotech	Interviews & Research Workshop	Tabulated data **Innovative Measures:** Multiple innovation performance measures; financial, operational, innovation and industry growth	New management systems and practices should be adopted if the innovation cycle in biotech firms is to be accelerated Managers need to adopt a more entrepreneurial approach to keep their firm competitive
Van Moorsel *et al.* (2007)	Innovation performance; Factors affecting biotechnology innovative activity in Canada (R&D capacity, access to outside knowledge, capital	Archival data (Statistics Canada's 2001 Biotechnology Use and Development Survey)	Ordinary Least Squares (OLS) Regression analysis **Innovative Measures:** Number of products & processes at different stages of the innovation spectrum	Factors that had a significant impact on innovation activity; defined as, total number of products & processes across all stages of development included collaborative alliances, firm size, transfer of intellectual property, whether the firm concentrated on

	requirements and usage, firm and sector characteristics, strategic focus of the firm)			development or commercialization, firm age and if the organization was in the agriculture or therapeutic sector

A firm-level analysis by Bagchi-Sen and Scully (2004) assessed financial metrics in the Canadian biotechnology landscape and, R&D intensity (the percent of total revenue used for R&D in relation to innovation), but did not address the impact of the organizational variable of culture on innovation performance. Baum *et al*. (2000) assessed alliance networks in new biotech firms (start-ups) to determine whether spatial organizational structures enhanced early performance. Baum *et al.* (2000) found that alliance networks produce significant differences in early innovation-related performance (patenting) but absorptive capacity and culture were not explored. Gittelman (2006) contrasted innovative performance in France and the US by comparing patent citations. Gittelman's study highlighted the importance of institutions (organizational cultural differences) and their impact on combinations of human capital and firm capabilities (Gittelman, 2006). Overall, in France, even with access to venture capital, as well as formal policies to encourage university technological transfer, France's commercial outputs lagged behind the US (Gittelman, 2006). A subset of culture, leadership, expressed as CEO characteristics was shown to have a positive and significant impact on the innovation outputs (patents) of Korean biotech firms (Kang and Lee, 2008). Hall and Bagchi-Sen (2002) examined R&D intensity, measures of innovation and firm performance but the authors did not address the so-called organizational "intangible assets" that may influence innovation performance such as organizational culture. A similar study done in the US biotechnology industry (Hall and Bagchi-Sen, 2007) suggested that innovation performance is related to R&D intensity as well as innovation strategies. The study by Hall and Bagchi-Sen (2007) addressed factors associated with R&D intensity (e.g., internal research capability, access to university collaborations, access to venture capital, etc.) but, similar to the earlier Canadian study, the research did not explore the relationship with intangible assets.

A study by Omta *et al*. (1994) addressed innovation performance in the pharmaceutical industry and evaluated innovation performance based on patent numbers and length of development. Even though the study was outside of biotechnology it addressed technological innovation and the R&D process. Pharmaceutical companies typically differ from biotechnology firms in many areas; specifically in, size (sales volume, number of employees), scale of business activities (global in reach) and organizational age. The authors found that in highly uncertain environments, in-house communications are an important dividing parameter in firm performance (Omta *et al*., 1994). Omta *et al*. (1994) reinforced the importance of human factors in research including human resources management, administrative procedures, flexibility, attention to building and maintaining networks and internal communications (Omta *et al*., 1994). As the innovative process of biotechnology is R&D intensive, it is assumed that these same “human factors” identified in the pharmaceutical industry study by Omta *et al.* would also apply to innovative performance in biotechnology firms. Van Moorsel *et al*. (2007) identified key drivers for innovation including collaborative arrangements, firm size, firm age and transfer of intellectual property. The criteria used to measure innovative activity by van Moorsel *et al.* (2007) was the total number of products/processes across all stages of development for the firms included in the study. Nevertheless, with the exception of the inclusion of collaborative arrangements, van Moorsel‘s primary research focus was not on organizational aspects and their impact on innovation performance. Woiceshyn and Hartel (1996) assessed performance based on sales, and the differences in performance between groups were based on skills outside of R&D and effective transfer of organizational learning (Woiceshyn and Hartel, 1996). Overall, in reviewing the literature associated with innovation and performance in the biotech industry, organizational aspects such as culture have received little attention from researchers.

2.2 Organizational Research in Biotechnology:

The organizational research that exists in the biotechnology landscape tends to be associated with firm characteristics, spatial organizational structures (clusters) and, collaborative arrangements (strategic alliances and networks) as well as management practices and needs (Aharonson *et al*., 2008; Audretsch and Feldman, 2003; Bagchi-Sen and Scully, 2004; Baum *et al.,* 2000; Decarolis and Deeds, 1999; Hunter, 2002; Hall and Bagchi-Sen, 2002; Hall and Bagchi-Sen, 2007; Kang and Lee, 2008; Niosi and Bas, 2001; Nosella *et al.*, 2006; Powell *et al*., 1996; Traore, 2004; Traore, 2006; Sabourin and Pinsonneault, 1997; Terziovski and Morgan, 2006; van Moorsel *et al*., 2007; Woiceshyn and Hartel,1996). No classic framework has been used to investigate the predominant organizational type (structure) within the Canadian biotechnology industry; however, networks and collaborative alliances are common.

2.2.1 Firm Characteristics:

Organizations within the Canadian biotech industry are typically small, 48% of organizations have fewer than 20 employees (BIOTECanada, 2008) and over 70% have fewer than 50 employees (Traore, 2006). Despite a firm's small size, research has shown that small entrepreneurial organizations can contribute considerable innovative potential especially in new industries (Audretsch and Feldman, 2003; Gittelman, 2006). In regards to firm size and its impact on innovative activity the data are inconclusive. Hall and Bagchi-Sen (2002) concluded that firm size (one to 50 employees) is not an accurate indicator of innovation based on new product introductions. In addition, in terms of patent applications and approvals, small firms had a less than average number (Hall and Bagchi-Sen, 2002). However, in the work done by van Moorsel *et al*. (2007) firm size was found to have an impact on innovative activity based on the innovation measure of total products and processes across all stages of development and not patent counts. Kang and Lee (2008) found that firm size had a positive effect on innovation performance, defined in terms of patent counts.

Firm age reflects organizational experience that may lead to easier innovation and, based on van Moorsel, *et al*. (2007), is a driver of innovation. Firm age, implying knowledge and experience, is an important factor for the development of products at the R&D stage (Traore, 2004). Assessing biotech companies based on their sector will reduce within-industry differences that may confound results and inferences (George *et al*., 2001). In the biotechnology industry differences in innovation have been found to exist based on industry sector; however, the data is sparse. Van Moorsel *et al*. (2007) found that the agricultural biotech sector had greater innovative activity however innovative activity was based on the number of processes and products and not patents. Furthermore, Marsh and Oxley (2005) did detect significant differences in innovative outputs between industry groups in the New Zealand biotech landscape. Overall, the literature on the impact of firm characteristics (firm size, age and biotech sector) in relation to innovation performance is not as robust as that on absorptive capacity and collaborative alliances.

2.2.2 Collaborative Alliances:

Interfirm arrangements (e.g., research joint ventures) can help reduce the capital requirements of an innovative firm for developing new products and processes (Teece, 1996). Biotech organizations have embraced network designs as they attempt to lower fixed costs to extend survival through alliances and partnerships and improve the success of innovation (Lloyd, 2003; Traore, 2006). In the US, networks of interorganizational relationships are the centre of innovation in the biotechnology industry (Powell *et al.,* 1996). Many US biotech organizations are heavily dependent on alliances to fund R&D and commercialize products (Teece, 1996). In Canada, networking is common amongst biotechnology firms; however, most organizations would rather keep networking to a minimum (Traore, 2006).

Furthermore, the degree of networking varies, based on size, stage of product development and biotech sector (Traore, 2006). There has been a positive relationship between strategic alliances, also defined as collaborative arrangements and innovation as well as the speed of the innovation process (van Moorsel *et al.,* 2007; Baum *et al*., 2000). Van Moorsel *et al.* (2007) also outlined the need for managers to seek out collaborations and networks and improve on internal processes and competencies. Considering the impact that collaborative alliances have on innovation, the number of alliances that firms participate in should be obtained to determine their relationship with innovation performance. Collaborative alliances are usually measured in terms of counts and that is how this construct will be operationalized in this study.

2.2.3 Absorptive Capacity:

Absorptive capacity is a key capability for firms competing in knowledge-based industries and, as a result, absorptive capacity can provide organizations with a competitive advantage (Fofuri and Tribo, 2008; Lane and Lubatkin, 1998; Zahra and George, 2002). Consequently, organizations with greater absorptive capacity can be expected to outperform competitors (Fofuri and Tribo, 2008; Zahra and George, 2002). The most commonly used definition of absorptive capacity is cited from Cohen and Levinthal (1990): *"the firm's ability to value, assimilate, and apply new knowledge"* (Zahra and George, 2002, p.186). Traore defines absorptive capacity as, *"the stock of knowledge that helps a firm to recognize the value of new external information, assimilate it and apply it to commercial ends",* (Traore, 2004, p. 5). A firm's prior knowledge supplies the ability to recognize value and assimilate new information and it is these "abilities" that Cohen and Levinthal define as a firm's absorptive capacity (Cohen and Levinthal, 1990). Mowery and Oxley (1995) defined absorptive capacity as, *"a broad array of skills, reflecting the need to deal with the tacit components of transferred technology, as well as the frequent need to modify a foreign-sourced technology for domestic applications"* (Zahra and George, 2002, p. 186). However, organizational absorptive capacity is more than the sum of its parts; it also reflects an ability to exploit information and transfer knowledge within the firm (Cohen and Levinthal, 1990). More recently Zahra and George (2002) defined absorptive capacity as a dynamic capability; specifically, *"a set of organizational routines and processes by which firms acquire, assimilate, transform, and exploit knowledge to produce a dynamic organizational capability"* (Zahra and George, 2002, p. 186). Zahra and George's definition is divergent than the prior definitions of absorptive capacity developed in prior research by Cohen and Levinthal (1990) and Mowery and Oxley (1995) as Zahra and George viewed absorptive capacity as a dynamic capability (Zahra and George, 2002). Secondly, Zahra and George's definition suggests that the capabilities of absorptive capacity (acquire, assimilate, transform and exploit knowledge) are built upon each other, *"to produce a dynamic organizational capability"* (Zahra and George, 2002, p. 188). For this research initiative, absorptive capacity will be viewed as a dynamic organizational capability as the ability to acquire, assimilate, transform and exploit knowledge for commercial ends is a cumulative organizational process.

Firms invest in R&D to better acquire and use information (Stock *et al*., 2001). R&D has been used as a construct for absorptive capacity since there is an empirical relationship between R&D intensity and learning (Stock *et al.,* 2001). Based on the summary of the literature by Zahra and George in 2002 the majority of the key studies assessing the construct of absorptive capacity (Keller, 1996; Mowery and Oxley, 1995; Liu and White, 1997; Lane and Lubatkin, 1998; Cohen and Levinthal, 1990) have used R&D intensity, or a similar surrogate, as the measurement vehicle (Zahra and George, 2002). Overall, absorptive capacity has generally been operationalized by R&D intensity, specifically R&D investment as a proportion of sales (Cohen and Levinthal, 1990; Stock *et al*., 2001). Biotechnology is a high R&D intensity industry in comparison to other industries and, as a result, it is not uncommon to see R&D percentages (R&D as a percentage of sales) greater than 50% (Hall and Bagchi-Sen, 2001). Mean R&D intensity in previous Canadian biotech research has ranged from 42% to

56%, with some regions reaching close to 60% (Hall and Bagchi-Sen, 2002; Bagchi-Sen and Scully, 2004). In the US, Hall and Bagchi-Sen (2001) reported a mean R&D intensity of 42%. Overall, R&D intensity has been shown in numerous biotech studies to be positively correlated as a driver of innovation performance, patent generation (Hall and Bagchi-Sen, 2001; Hall and Bagchi-Sen, 2002; Hall and Bagchi-Sen, 2007; Kang and Lee, 2008; Marsh and Oxley, 2005; Powell *et al.*, 1996)

2.2.4 Firm Barriers to Innovation:

Access to capital is often viewed as a firm barrier, yet it is interesting to note that better access to capital at the R&D stage (product development stage) had no affect on creative capacity and did not improve the success of commercializing biotech products in the Canadian industry (Traore, 2004). Kang and Lee (2008) found that government support (subsidies, grants awards or loans) was positively correlated with an organization's innovation performance and absolute patent counts (Kang and Lee, 2008). However, the study was performed in Korea where the government's role becomes more important due to a lack of venture capitalists to invest in small and medium sized biotech firms (Kang and Lee, 2008). Government support, defined as funding for research and technical training, is important for firms that utilize high levels of their resources for R&D (Hall and Bagchi-Sen, 2007). The ability to access venture capital for high R&D intensity firms is considered critical for innovation performance (Hall and Bagchi-Sen, 2007; Teece, 1996). Considering that Canada is positioned close to capital markets, unlike the Korean biotech industry, it is assumed that Canadian biotech firms will obtain access to funds from both venture capitalists and government. Of great importance to the Canadian biotechnology sector is the impact of resource constraints (barriers to innovation) specifically, government support, access to venture capital and recruiting and retaining biotech talent (human resources). The importance of the biotech industry justifies government involvement to assist industry development (Terziovski and Morgan, 2006). For Quebec biotech firms, a lack of access to government research funds is considered a significant barrier (Bagchi-Sen and Hall, 2002). In Canada, in 2007 – 2008 the federal government spent $921 million to support biotech R&D through science and technology activities (Public Policy Forum, 2009). Overall, Canada ranks second in the OECD in terms of government-funded university research per capita, but only 14th out of 20 OECD countries on business R&D expenditures (Public Policy Forum, 2009). Funding is the lifeblood of biotech firms (Bagchi-Sen and Hall, 2002) and in Canada the availability of investment capital along with the commitment of government has provided support for the growth and spread of the industry. US firms that invest heavily in R&D have also indicated that access to venture capital is very important (Bagchi-Sen and Hall, 2007).

The recent Canadian Blueprint from BIOTECanada identified attracting investment for commercialization as one of the biggest challenges facing the industry and emphasized the need over the next five years to stimulate new capital formation (BIOTECanada, 2009). However, this does not appear to be a new challenge as 70% of Canadian biotech firms considered funding related problems to be a major obstacle in the mid 1990s (Woiceshyn and Hartel, 1996). Another key challenge, identified by BIOTECanada, is for biotechnology to attract and retain high quality talent (researchers and commercial managers) to grow the industry (BIOTECanada, 2009; BioTalent, 2008). The most important barrier to innovation reported by biotech firms in British Columbia was a lack of skilled managers (Bagchi-Sen and Hall, 2002). The ability to attract human resources talent, both scientists and management is dependent on the continual support of funding from government and private sources. Considering the current challenges the biotech industry faces in Canada, potential barriers to innovation performance such as government support, access to venture capital and biotech talent should be explored.

2.2.5 Biotech Culture:

There has only been limited work on culture in the biotechnology industry and no research on culture's impact on Canadian biotech firms. Furthermore, there were only two studies in the biotech industry that could be identified that addressed culture in regards to its impact on innovation. In a study of the biotechnology sectors in the US and France, Gittelman (2006) found that patenting, licensing revenues and venture capital were comparable between the two countries based on their relative size however, France lagged behind the US in developing commercial applications for biotech products. Cultural differences between the US and French research scientists (the competitive entrepreneurial system of science in the US) and knowledge flows lead to the differences in commercial outputs from the biotech sectors (Gittelman, 2006). Biotech start-ups from the United States and Scandinavia were analyzed based on their market and entrepreneurial orientation (Renko *et al.,* 2009). Market orientation was based on firm culture that placed the customer first while entrepreneurial orientation emphasized innovation (Renko *et al.*, 2009). Market orientation was measured by an adapted MARKOR scale from Jaworski and Kohli (1993) and entrepreneurial orientation was assessed by an eight-item entrepreneurial scale from Knight (1997) (Renko *et al.*, 2009). There was no link found between market and entrepreneurial orientation and product innovativeness measures (new product introductions, NPD projects started and end products developed by the firm). However, the author's indicated that their; "*entrepreneurial orientation construct materializes in the form of new product innovations"* (Renko *et al.*, 2009, p. 361) which considering the significant development time for products in biotechnology is not the best measure of innovation performance, patents would be more appropriate.

Since a significant percentage of Canadian biotech firms have incomplete management teams, such gaps in top management could lead to deficiencies in organizational function (Woiceshyn and Hartel, 1996). There is strong evidence that management capabilities and not just R&D, technology and research capacity is critical for innovation (Volberda and van den Bosch, 2005; Hall and Bagchi-Sen, 2007). The work done by van Moorsel *et al.* (2007) addressed innovation in the Canadian biotechnology arena by concluding that managers should develop methods to improve their own capabilities as well as the firm's innovative pipeline. Overall, for successful innovation to occur leadership skills are important competencies for managers to develop as executive power and personality can affect the innovation cycle (Prajogo and Ahmed, 2006;Terziovski and Morgan, 2006). Leadership, within the context of this research initiative, is related to management teams and their influence on innovation performance. Cultural impact on leadership was outlined in Fred Fiedler's contingency theory (Fiedler, 1978) of leadership which stated that different leadership personalities are required for difficult versus easy situations and the cultural gap between a manager and his or her direct report can make the situation difficult (Hofstede, 1980).

Many biotech companies are relatively new firms, small in size and founded by one or two entrepreneurs and, as such, the founder embeds a culture based on his/her leadership style that could impact innovation performance (Alegre *et al.,* 2009). Founders have the most important impact on the beginning of firm cultures (Schein, 2004; Schein, 2009) and considering the start-up nature of most biotech firms, founders are considered to be a major influence on biotech culture. For instance, the characteristics of Korean biotech CEOs was positively and significantly linked to a firm's innovation outputs (patents) (Kang and Lee, 2008). The founder establishes a definable organization, with a culture, based on his or her interaction with the people of the firm. Several reports have indicated that in order to accelerate biotech innovation managers need to be more entrepreneurial and, as such, a cultural change that encourages greater risk-taking is required (Public Policy Forum, 2009; Terziovski and Morgan, 2006). Table 2 outlines organizational research in the biotechnology industry.

Table 2: Organizational Research in the Biotechnology Industry

Author(s)	Focus of the study	Method of data collection	Method of data analysis
Aharonson *et al.* (2008)	Inventive and uninventive biotechnology clusters	Archival data	Negative binomial models and descriptive statistics
Audretsch and Feldman (2003)	Small firm strategic partnerships (alliances)	Literature review	Empirical literature review
Bagchi-Sen and Scully (2004)	Innovation and business development – a firm level analysis • Firm level characteristics were obtained	Survey (Questionnaire)	Descriptive data
Baum *et al.* (2000)	Strategic alliance networks	Life histories	Regression analysis
DeCarolis and Deeds (1999)	Flows of organizational knowledge and firm performance	Database assembly (Prospectus from firm IPO)	Regression analysis
Gittelman (2006)	Organizational aspects and their impact on innovation – culture & knowledge flows	Archival Data & Interviews	Negative binomial models – patent citation counts
Hall and Bagchi-Sen (2002)	Relationship between R&D Intensity, innovation measures and business performance • Firm level characteristics were obtained	Survey (Questionnaire)	Chi-square statistics, Spearman's non-parametric correlation statistics & measurement development
Hall and Bagchi-Sen (2007)	Factors that affect innovation strategies and performance (R&D Intensity) • Firm level characteristics were obtained	Survey (Questionnaire)	Chi-square statistics, Spearman's non-parametric correlation statistics & measurement development
Hunter (2002)	Organizational design in research based firms	Case study research	Analysis of structural elements
Niosi and Bas (2001)	Spatial organizational competency – clusters in biotech	Archival	Empirical analysis

Powell *et al*. (1996)	Interorganizational collaboration & networks of learning	Database assembly	Regression analysis
Renko *et al.* (2009)	The effect of market & entrepreneurial culture orientation and technological capability on product innovativeness	Interviews	Multiple Linear Regression and t-tests
Sabourin and Pinsonneault (1997)	Competitiveness of biotechnology clusters • The role of strategic resources in the Canadian biotech industry – highly qualified manpower, and knowledge resources	Interviews, focus groups & questionnaires	Descriptive analysis
Traore (2004)	Creative capacity – the role of absorptive capacity, relational capital, learning and firm characteristics	Survey (Questionnaire)	Regression analysis
Traore (2006)	Networks (inter-organizational relationships) and rapid technology change	Archival data (BUDS 2001)	Regression analysis
Terziovski and Morgan (2006)	Management Practices & strategies to accelerate the innovation cycle	Interviews, mini-case studies & workshops	Data tabulation
Van Moorsel *et al.* (2007)	Factors affecting biotechnology innovation (Firm characteristics were obtained - R&D capacity, access to outside knowledge, capital requirements and usage, firm and sector characteristics, strategic focus of the firm)	Archival data	Regression analysis
Woiceshyn and Hartel (1996)	Empirical investigation - Strategies and Performance • Organizational aspects such as; management teams, complementary skills and organizational learning were explored	Survey (Questionnaire)	Descriptive & Exploratory

2.3 Organizational Culture:

In the 1970s the term “corporate culture” was first introduced and, following a 1980 article on corporate culture published in Business Week, a significant level of interest from researchers and the business community followed (Allaire and

Firsirotu, 1984; Meek, 1988; Morcillo *et al*., 2007). Focus on the concept of culture has generated an increasing body of literature on organizational culture as researchers realize that firm systems and structures are impacted by core values and assumptions (Morcillo *et al*., 2007). The increasing importance of culture is also a result of the changes, turbulence and complexity faced by organizations and an understanding that core values and assumptions affect firm systems and structures (Cameron and Quinn, 1999; Denison and Spreitzer, 1991). There are numerous papers that outline the theoretical foundations of culture (Deal and Kennedy, 1982; Schein, 1985; Cameron and Ettington, 1988; Trice and Beyer, 1993); however, the concept of organizational culture emerged from two different disciplines: anthropology and sociology (Cameron and Quinn, 1999; Meek, 1988; Schein, 1988). Organizational culture differs from individual culture as it is not associated with the values and preferences of the individual but rather the entire firm as the unit of analysis. The origins of a firm's culture come from three sources: the founders, the learning experience of the group or recent values and beliefs that new members and leaders bring to the organization (Schein, 2004).

The literature, although robust in terms of research on organizational culture has no formal definition of the term, although many different definitions exist ranging from mentalist to social constructivist (Barney, 1986; Ngwenyama and Nielsen, 2003). A summary of the literature by Allaire and Firsirotu identified unique definitions of culture for eight different schools of cultural anthropology ranging from functionalist to symbolic. The different anthropologic concepts alone lead to divergent views of what firm culture might represent and signify (Allaire and Firsirotu, 1984). Schein defined culture from the functionalist anthropological paradigm, viewing it as: *"a pattern of shared basic assumptions that was learned by a group as it solved its problems of external adaptation and internal integration, that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems."* (Schein, 2004, p. 17). Schein (1985) went on to further define corporate culture as: "*a group of behaviors, norms, accepted dominant values, philosophy, game rules and the atmospheres or climate existent in a company"* (Morcillo *et al*., 2007, p. 548). Hofstede viewed culture in terms of cultural conditioning and defined culture as; *"the collective mental programming of the people in an environment"* (Hofstede, 1980, p. 43). Cameron and Quinn offered two very similar definitions of culture, as Cameron *et al*. (2006) defined it as; *"the core values, assumptions, definitions, and memories embedded in an organization"* (Cameron *et al*., 2006, p. 120) while Cameron and Quinn (1999) viewed organizational culture as, *"the values, underlying assumptions, expectations, collective memories, and definitions present in an organization"* (Cameron and Quinn, 1999, p. 14).

Organizational culture can also be viewed in terms of what an organization "has" versus what an organization "is"; the former representing the sociological foundation and the later the anthropological foundation. (Meek, 1988; Smircich, 1983). Culture has also been defined in terms of metaphors, as the image of an organization is viewed in terms of an organism (Smircich, 1983). Morgan (2006) indicated that; *"one of the strengths of the culture metaphor is that it directs attention to the symbolic significance of aspects of organizational life"* (Morgan, 2006, p.142). The culture metaphor also identifies one of the key roles of managers and leaders, which are to shape the firm through the influence of values, beliefs, norms and ceremonies in order to guide the efforts of people in pursuit of common objectives (Morgan, 2006).

Overall, organizational culture is built on common (shared) values, ideas, underlying assumptions, expectations and plays a key role throughout the organization. The definition of organizational culture applied in this research is based on the functional sociological perspective and, as such, culture is viewed as an enduring set of core values, beliefs, definitions and assumptions that characterize organizations and their members. The view is taken that differences in firm culture can be identified, culture is a phenomenon which can predict firm outcomes and culture is an attribute that can be measured in an organization.

Even though definitions of organizational culture vary, there appears to be agreement that culture is the foundation for the development of organizational actions (Ngwenyama and Nielsen, 2003). According to Schein there exist three major levels of culture in a firm: artifacts (the visible organization), exposed beliefs and values (strategies and philosophies) and underlying assumptions (beliefs and perceptions) (Schein, 1988; Schein, 2004).

Culture can be explored at many levels, from very broad to very narrow in scope. For instance, a culture can exist at a global, national or regional level. Culture can also exist in a specific industry or occupation. In terms of organizational culture, culture exists at the firm level but there are also unique cultures at the subunit level such as in functional departments, work teams, product groups or even at hierarchical levels. In addition, the various levels of culture may impact measures of innovation performance in different ways. Considering the broad level of metrics that have been applied to measure innovation performance (e.g., patents, new product and process introductions, R&D efficiency, trade secrets, number of formulations entering clinical trials, new research programs, profitability, citation rate, etc.) there exists the potential for multiple combinations of cultural and innovation performance interactions. Consequently, it is important to note that this research initiative will explore culture at the organizational level and use aggregate patent output as the measure of innovation performance.

It has been proposed that organizational culture is a key barrier for leveraging new information and applying technical innovation (Helfrich *et al*., 2007). Consequently, organizational culture continues to evolve as a variable; thus, culture and innovation have been defined by Morcillo as; *"a form of thinking and of acting that generates, develops and establishes values and prone attitudes to raise, assume and still impel ideas and changes that suppose improvements in* *the operation and efficiency of the company, in spite of it implies a rupture with the conventional or traditional"* (Morcillo *et al*., 2007, p. 548). The culture of innovation was also defined by Cameron and Quinn, 1999 as; *"the organization's level of adaptability, flexibility, creativity, coexistence with the uncertainty and the ambiguity of the information, absence of centralized power and of very established control chains, emphasis in the individuality, in the risk and in the anticipation"* (Morcillo *et al*., 2007, p. 548).

There exists disagreement amongst researchers with regard to the measurement and dimensions that characterize culture (Cameron and Quinn, 1999). Definitions of culture refer to the structural concept of culture and there exists a wide variety of scholarly work on the dimensions of culture (content). A review of the literature by Cameron and Ettington in 1998 identified more than 20 dimensions of organizational culture however, the three most common and dominant dimensions in the literature were cultural strength, congruence and type (Cameron and Quinn, 1999). Debate continues on whether it is best to measure culture through quantitative or qualitative measures. Since culture is based on in-depth assumptions and values; utilizing a questionnaire approach to measure culture is felt by many to provide only superficial insights since to obtain a comprehensive understanding of organizational culture, culture must be experienced as many elements of culture are deeply embedded (Cameron and Quinn, 2006; Denison and Spreitzer, 1991; Schein, 2009). The opposing view is that a quantitative approach provides the advantage of investigating many organizations at once, which would be impossible if full immersion in one organization was necessary (Cameron and Quinn, 2006). Ethnographic research may also take months or years to complete (Denison and Spreitzer, 1991). The debate about qualitative or quantitative methodology appears to be secondary to the primary goal of obtaining data that can generate the greatest insight into the evolution and influence of culture in organizations (Denison, 1996).

3.0 Theoretical Framework

3.1 <u>The Competing Values Framework</u>:

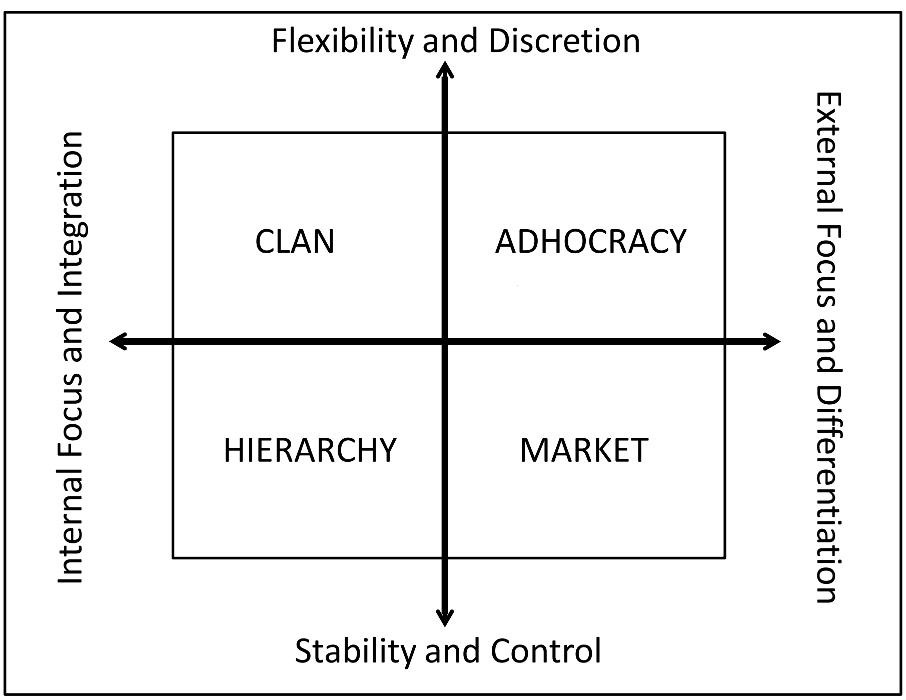
The theoretical framework that is applied in this research initiative to explore the organizational aspect of culture is the Competing Values Framework (CVF). This was initially developed as a conceptual framework in the 1980s as a tool to explain the differences in values underlying organizational and management performance, specifically organizational effectiveness (Denison and Spreitzer, 1991; Quinn and Rohrbaugh, 1983; Quinn *et al.*, 1991).

Even though the CVF was initially developed as a tool to investigate organizational effectiveness and analyze firm and managerial performance, it has been applied to explore a wide variety of organizational phenomena and is one of the most widely used models in the area of cultural quantitative organizational research (Yu and Wu, 2009). Furthermore, the CVF has been rated as one of the top fifty key frameworks in business research (Cameron *et al.*, 2006; Igo and Skitmore, 2005). Overall, the CVF is viewed as a very robust tool that has been applied by researchers to investigate many aspects of organizations including leadership, corporate strategy, quality and organizational culture (Cameron *et al.*, 2006). It provides flexibility as it does not subscribe to any single definition of an organization but has a broad interpretation based on the underlying values as the foundation of a firm's design and structure (Denison and Spreitzer, 1991). The CVF makes an assumption that firm characteristics based on cultural traits or dimensions common to all organizations exist (Denison and Spreitzer, 1991). Surveys utilizing a "scenario analysis" in which the scenarios serve as cues to provide insight into core cultural attributes have been used in many studies, the CVF is built on scenario analysis (Cameron and Quinn, 1999) and is based on the functionalist, sociological definition of culture, in which culture is viewed as an attribute of the organization that can be measured empirically (Cameron and Quinn, 2006). The CVF model (Please refer to Figure 2) consists of two dimensions built on axes that reflect the tensions of conflicting demands on an organization (Quinn *et al*., 1991).The two dimensions are;

- **1st Dimension (x-axis): Internal Focus/Integration – External Focus/Differentiation**
    - The first dimension reflects differences in organization concentration by contrasting internal versus external organizational focus (Quinn and Rohrbaugh, 1981; Quinn and Rohrbaugh 1983).

- **2nd Dimension (y-axis): Flexibility/Discretion – Stability/Control**
    - The second dimension contrasts organizational structure and different preferences for flexibility versus stability (Quinn and Rohrbaugh, 1981; Quinn and Rohrbaugh 1983).

Figure 2: The Competing Values Framework



Source: Cameron and Quinn, 1999.

These two dimensions define four quadrants (Clan, Adhocracy, Hierarchy and Market) each representing alternative approaches to organizational challenges based on organizational theory. The dimensions form a model that, *"illustrates the conflicts, or competing values of organizational life"*. (Quinn *et al.,* 1991, p.217). For instance, managers want a firm to be flexible but they also want stability.

The four-category cultural typology of Cameron and Quinn (1999) based on the two-dimensions; stability versus flexibility and internal versus external, are seen as continually competing values (Schein, 2004). The typology was built by analyzing indicators of firm performance that were associated with what researchers have identified as archetypical dimensions (Schein, 2004). The dominant cultural archetype of a firm (i.e. Clan, Hierarchy, Market or Adhocracy) can be identified by focusing on core attributes such as basic assumptions, orientations and values (Cameron and Quinn, 1999; Igo and Skitmore, 2006). Within each cultural archetype there exists a dominant leader type, effectiveness criteria and management style. Outlined below are details of the four cultural archetypes:

> **Clan Culture:** A culture of shared values, commitment, open communication, common goals, mutual help, employee involvement, strong interactions among members, loyalty, cohesiveness, teamwork, consensus and participation. The organization is like an extended family and customers are viewed as partners. Leaders tend to be team builders, mentors and are supportive. The focus is on internal maintenance with flexibility, concern for people and sensitivity to constituents. The firm orientation is collaborative (Boggs, 2004; Cameron and Quinn, 1999; Cameron and Quinn, 2006; Cameron and Freeman, 1991; Denison and Spreitzer, 1991; Igo and Skitmore, 2006; Yu and Wu, 2009).

Adhocracy Culture: A dynamic, creative and entrepreneurial place to work where the leaders are visionary risk takers and success is based on innovation and producing unique original products and services. Creativity and risk-taking are valued and employees constantly try new things with an emphasis on being on the leading edge. Leaders tend to be innovative and entrepreneurial. The focus is on external positioning and there is a high degree of flexibility and autonomy. The firm orientation is creative (Boggs, 2004; Cameron and Quinn, 1999; Cameron and Quinn, 2006; Cameron and Freeman, 1991; Denison and Spreitzer, 1991; Igo and Skitmore, 2006; Yu and Wu, 2009).

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Hierarchy Culture: A culture of stability, structure, efficient-minded management (bureaucracy), predictability and control with clear tasks and enforcement of rules, formal procedures and order. Leaders tend to be conservative, organizing and monitoring. The focus is on internal maintenance with a need for stability and order. The firm orientation is controlling (Boggs, 2004; Cameron and Quinn, 1999; Cameron and Quinn, 2006; Cameron and Freeman, 1991; Denison and Spreitzer, 1991; Igo and Skitmore, 2006; Yu and Wu, 2009).

Market Culture: A competitive, goal-oriented, achievement-based culture. Activities are externally oriented with centralized power. Effectiveness is assessed based on market share and profitability with an emphasis on winning. Leaders tend to be goal oriented, decisive and competitive. The focus is on external positioning with a need for stability and order. The firm orientation is competing (Boggs, 2004; Cameron and Quinn, 1999; Cameron and Quinn, 2006; Cameron and Freeman, 1991; Denison and Spreitzer, 1991; Igo and Skitmore, 2006; Yu and Wu, 2009).

Based on the Competing Values Framework, the leadership style displayed by managers matches a corresponding culture typology that supports and shares common values (Cameron and Quinn, 1999; Cameron and Freeman, 1991). The most effective leaders are aware of their organization's culture and their leadership styles tend to match the firm's culture (i.e. culture and leadership are linked). Cameron and Quinn suggest, through their research, that leadership and management are interconnected and both are needed for organizational effectiveness, *"Leaders who are not managers are bound to fail, just as managers who are not leaders are bound to fail"* (Cameron and Quinn, 1999, p. 70). Based on the CVF, the management competencies of all four cultural types; clan, adhocracy, market and hierarchy are valued (Cameron and Quinn, 1999). Key assumptions of the CVF model are that: all four cultural archetypes operate at an organizational level; the firm is unlikely to have just one culture type but tends to have a combination of typologies, with some being more dominant; culture is expressed in the views of the firm's employees; and the culture remains generally stable over time (Cameron and Quinn, 1999; Denison and Spreitzer, 1991).

In this study, the CVF of Cameron and Quinn is selected as the lens through which to explore organizational culture for the following reasons;

- Firstly, the competing values framework has been validated as an effective tool to investigate organizational culture and leadership transformational change (Hooijberg and Petrock, 1993; Cameron and Quinn, 1999).

- Secondly, the framework has become a dominant model in quantitative cultural research with numerous published studies confirming validity and reliability (Yu and Wu, 2009). It therefore is beginning to represent a common evaluation currency in this domain.

- Thirdly, it is a framework that provides reliable aggregated quadrants (subscales) given labels that distinguish the firm's most notable characteristics (Quinn *et al.,* 1991).

- Fourthly, the framework emphasizes the different values of schools of organizational theory that are embedded in management practices (Denison and Spreitzer, 1991; Ngwenyama and Nielsen, 2003; Quinn *et al.*, 1991).

- Finally, Cameron and Quinn have developed a matched validated survey tool based on the CVF, the Organizational Culture Assessment Instrument (OCAI). The OCAI has been used to assess culture in over a thousand organizations and can be applied over a range of organizations to obtain insight into organizational culture (Cameron and Quinn, 1999).

The "Organizational Culture Assessment Instrument" (OCAI) designed by Cameron and Quinn (1999) and based on the Competing Values Framework will be the instrument used to obtain data from the target population (Canadian biotech firms). The OCAI focuses on firm core attributes (i.e. dominant characteristics, organizational leadership, management of employees, organizational glue, strategic emphasis and criteria of success) that allow for identification of an organization's cultural type. The OCAI has a number of benefits including: empirical evidence of reliability and validity as a culture instrument, practicality, manageability, validity in cross cultural research and both quantitative and qualitative application (Cameron and Quinn, 1999; Cameron and Quinn, 2006; Cameron and Freeman, 1991; Quinn and Spreitzer, 1991; Yu and Wu, 2009). The OCAI can be used to identify a firm's culture profile (Clan, Hierarchy, Adhocracy and Market) based on core values, assumptions, interpretations and approaches that characterize organizations (Cameron and Quinn, 1999).

It is important for a firm's culture to be compatible with the demands of the competitive environment and a lack of congruence affects organizational success (Cameron and Quinn, 2006). In biotechnology, a culture of innovation, flexibility, creativity and entrepreneurship is required and, as such, an "adhocracy" culture would be more appropriate for the competitive environment that biotech firms function in. An adhocracy culture is described as:

"A dynamic, entrepreneurial, and creative place to work. People stick their necks out and take risks. The leaders are considered to be innovators and risk-takers. The glue that holds the organization together is commitment to experimentation and innovation. The emphasis is on being on the leading edge. The organization's long-term emphasis is on growth and acquiring new resources. Success means gaining unique and new products or services. Being a product or service leader is important. The organization encourages individual initiative and freedom." (Cameron and Quinn, 2006, p.66).

<u>It is hypothesized that</u> biotechnology firms that have high levels of innovation performance will be dominated by an adhocracy culture profile.

3.2 <u>Research Model</u>:

Overall, there is no current framework that exists depicting the constructs that impact innovation performance, although Kang and Lee (2008) did provide a conceptual model for biotechnology firms. The model that Kang and Lee proposed in their 2008 research includes R&D intensity (absorptive capacity) and collaborations (networking) as well as corporate size (number of employees). Perhaps the lack of a framework stems from the fact that the term, "innovation performance", has not been clearly defined in the literature and is used by researchers based on what measures or aspects of innovation they are addressing. From the literature review there exist a significant level of data to support the impact of R&D intensity (absorptive capacity) and collaborative agreements (R&D alliances) on innovation performance (defined in terms of patents) in the biotechnology industry.

Firm characteristics, including size and age, will be included in the proposed model to serve as control variables, although robust data in the literature are lacking. The rationale for the support of size and age as controls and inclusion in the model are outlined below;

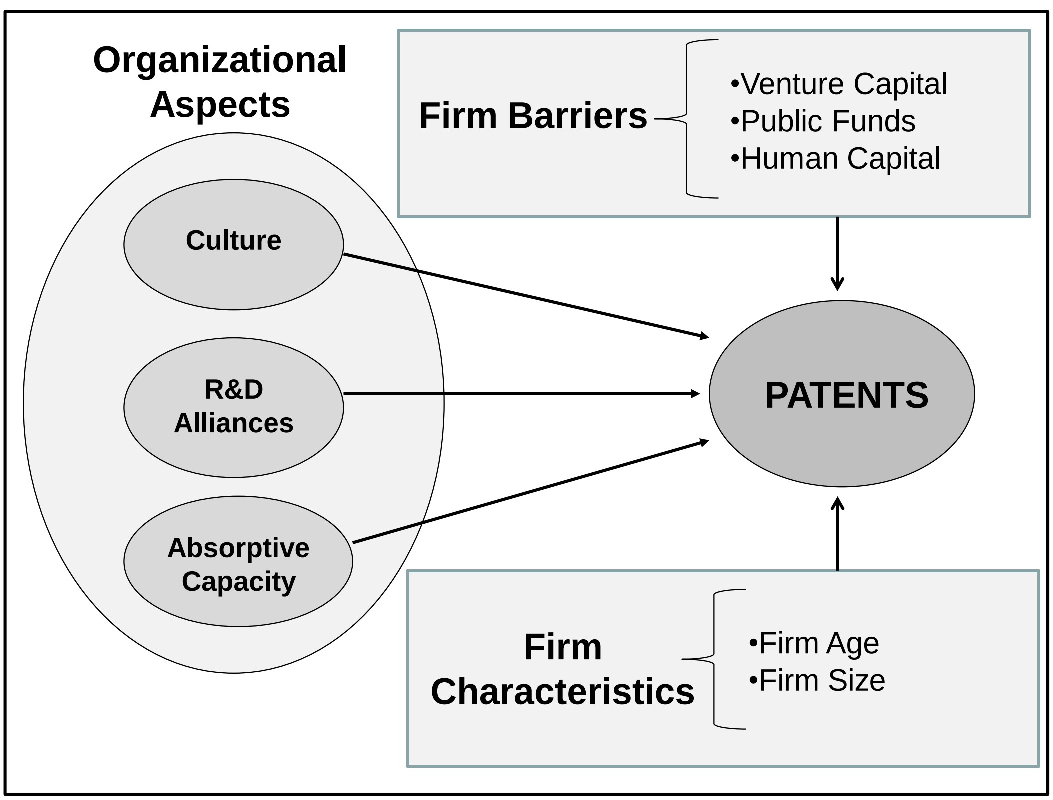
- Increasing biotech firm size (measured by number of employees) had a positive relationship on Korean biotech innovation performance as a control variable (Kang and Lee, 2008). However, in New Zealand, smaller biotech firms, based on the number of employees had a higher innovation rate (Marsh and Oxley, 2005). The debate often focuses on the entrepreneurial culture of small versus medium and large firms contrasting the availability of resources versus bureaucratic behavior (van Moorsel *et al.*, 2007).

- Biotech firm age (measured in years) has had a positive impact on innovation as it carries the association of experience that may make innovation easier (van Moorsel *et al.,* 2007). Age needs to be controlled for to ensure that any significant innovation performance is not just a result of age-related outputs (Baum *et al*., 2000).

Of key importance to the Canadian biotechnology sector at this time is the impact of resource constraints (barriers to innovation). As outlined in the literature review, access to venture capital, government support and human resources have been identified as variables that may impact innovation (Bagchi-Sen and Hall, 2002; Bagchi-Sen and Hall, 2007; BIOTECanada, 2009; Kang and Lee, 2008; Public Policy Forum, 2009; Terziovski and Morgan, 2006; Woiceshyn and Hartel, 1996). The key addition to the research model is the construct of “organizational culture”.

Innovation performance will be measured through firm patent outputs (US & international patent applications (Patent Cooperation Treaty); US & international patent approvals). A conceptual model is presented in Figure 3 depicting the theorized connection between the organizational aspects of culture, absorptive capacity, collaborative alliances, firm barriers, firm characteristics and their impact on innovation performance. Based on the conceptual model, it is proposed that three phenomenon have significant impact on innovation performance within the Canadian biotech industry: organizational culture, absorptive capacity and collaborative alliances. Barriers to innovation (resource constraints), specifically venture capital, public funding and human resources; will also be investigated in terms of their impact on innovation performance. Firm characteristics such as, age and size also impact innovation performance and will serve as control variables.

Figure 3: Innovation Performance Conceptual Model



3.3 Hypotheses:

The fundamental conjecture of this research is; *"Does the organizational aspect of culture have an impact on the innovation performance of Canadian biotechnology organizations?"*

The hypotheses include:

Hypothesis 1: *Organizational culture has a significant impact on innovation performance for firms in the Canadian biotechnology industry.*

Hypothesis 2: *The dominant culture for firms in the Canadian biotechnology industry is the "adhocracy culture" based on the Competing Values Framework.*

Hypothesis 3: *An "adhocracy culture" is associated with higher levels of innovation performance for firms in the Canadian biotechnology industry.*

4.0 Empirical Test

4.1 Operationalization of Variables:

Dependent variable:

Innovation Performance – A measure of aggregate output of firm patent applications and patent approvals over a five year time period (2005 – 2009).

1. United States patent applications
2. International patent applications (Patent Cooperation Treaty)
3. United States patent approvals
4. International patent approvals

References: Patents are well cited as a measure of innovation outputs. (Baum *et al*., 2000; Bagchi-Sen and Scully, 2004; George *et al*., 2001; Hall and Bagchi-Sen, 2002; Hall and Bagchi-Sen, 2007; Marsh and Oxley, 2005; Mohen and Therrien, 2002; Terziovski and Morgan, 2006; Traore, 2006; van Moorsel *et al*., 2007).

Independent variables:

Culture – Measured using the Organizational Culture Assessment Instrument (OCAI), based on the Competing Values Framework.

References: Cameron and Quinn, 1999; Cameron and Quinn, 2006.

Absorptive capacity – R&D Intensity; defined as the percentage of total revenues allocated toward R&D activity.

References: Cohen and Levinthal, 1990; Hall and Bagchi-Sen, 2001; Hall and Bagchi-Sen, 2002; Hall and Bagchi-Sen, 2007; Kang and Lee, 2008; Stock *et al.*, 2001.

For some biotech firms R&D spending as a proportion of firm sales will not be available as the organization may not have commercial sales. In situations where Biotech firms do not have revenues, it is assumed that R&D spending is 100%.

Collaborative Alliances – defined as the absolute number of R&D alliances (alliance counts)

References: Bagchi-Sen and Scully, 2004; Baum *et al*., 2000; George, *et al.*, 2001; Mohen and Therrien, 2002; Powell *et al*., 1996; Terziovski and Morgan, 2006; Traore, 2004; van Moorsel *et al*., 2007.

Firm Characteristics

- Firm Age – Age of the firm measured in years (Year of Establishment)
    - References: Traore, 2004; Traore, 2006; van Moorsel *et al*., 2007

- Firm Size – Defined as the number of employees
    - References: (Bagchi-Sen and Scully, 2004; Hall and Bagchi-Sen, 2002; Kang and Lee, 2008; Marsh and Oxley, 2005; van Moorsel *et al*., 2007; Woiceshyn and Hartel, 1996)

Firm Barriers

- Access to Venture Capital – Likert Scale (Access to venture capital is essential for innovation in your organization?)

- Access to Government funds – Likert Scale (Access to government funds is essential for innovation in your organization?)

- Access to Human Capital – Likert Scale (Access to human capital (scientific and commercial expertise) is essential for innovation in your organization?)

4.2 Research Methods:

4.2.1 Target Population:

The North American Industry Classification System (NAICS) code for the biotechnology industry is 541710. However, this code is very broad and includes biotech suppliers and engineering providers, medical technology companies, public/non-profit organizations and core biotech development firms (also known as dedicated biotechnology firms or the innovative biotech segment). Consequently, the bio-based economy, and more specifically biotechnology, can be segmented into smaller units of analysis.

The OECD definition for biotechnology is outlined below;

"*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*." (van Beuzekom and Arundel, 2009, p. 9.).

Statistics Canada also uses the OECD definition to define biotechnology firms in Canada. The definition can be operationalized to include; DNA/RNA, cell tissue and culture engineering, gene and RNA vectors, bioinformatics, process techniques, nanobiotechnology and proteins and other molecules (van Beuzekom and Arundel, 2009). There are two OECD subgroups for biotechnology firms;

- **Dedicated Biotechnology Firm:** *"Defined as a biotechnology firm whose predominant activity involves the application of biotechnology techniques to produce goods or services and/or to perform biotechnology R&D. Firms are captured by biotechnology firm surveys"* (van Beuzekom and Arundel, 2009, p. 14.).

- **Biotechnology R&D Firm:** *"Defined as a firm that performs biotechnology R&D. Firms are captured by R&D surveys"* (van Beuzekom and Arundel, 2009, p. 14.).

The key difference between the two subgroups is based on how governments collect data. For instance, if governments collect data based on biotechnology firm surveys, then the firms fall into the "Dedicated Biotechnology Firm" subgroup. If the survey is an R&D survey, then the firm will fall into the "Biotechnology R&D Firm" subgroup. For this research initiative the OECD subgroup, "Biotechnology R&D Firm" was used to define the sample population as it includes biotech firms that perform R&D and excludes those that may only be service orientated.

In Canada, 70% of biotechnology firms are located in Ontario, Quebec and B.C. with firms clustering in the key metropolitan centers of Toronto, Montreal and Vancouver (Industry Canada, 2008; BioTalent Canada, 2008). The sample population was drawn from BIOTECanada's Canadian Life Sciences Database (www.canadalifesceinces.com), the most comprehensive database of biotechnology firms in the country. Firms meeting the OECD subgroup criteria were identified from the following sectors of the Canadian Life Sciences database;

- Biotechnology-therapeutics
- Biotechnology-other
- Medical Technology
- Biotechnology/R&D Services

In addition, the memberships of the following key biotechnology associations were reviewed in order to ensure that a thorough data set of relevant Canadian biotech firms was compiled;

- LifeSciences British Columbia
- BioAlberta
- Toronto Biotechnology Initiative
- MaRS
- The Canadian Biotechnology Industry Guide (2009)
- BioAtlantech
- BioQuebec

Overall, over 90% of the survey population came from the Canadian Life Sciences' Database. In terms of the criteria defined by OECD as a Biotechnology R&D Firm, a total of 356 firms were identified. In previous research Bagchi-Sen and Scully (2004) and Hall and Bagchi-Sen (2002) had a target population of 332 and 443 firms respectively, although they both used the North American Biotechnology Directory.

4.2.2 Sampling Method:

The sampling instrument selected for the research was a standardized self-administered questionnaire. The survey was cross sectional and was selected as the sampling method for the following reasons;

- Quantitative nature of the research
- Low cost
- Rapid collection of data
- National reach to all firms of the sample population
- Collection of a sufficient sample size so that inferences can be made for the population
- Measurement of concepts not available through objective indicators

Due to the possibility of a low response rate the survey was mailed to all firms that comprised the target population (e.g., N=356) in order to achieve as high a response rate as possible. In previous Canadian biotech research, Bagchi-Sen and Scully (2004) and Hall and Bagchi-Sen (2002), the response rate ranged between 24% and 26%.

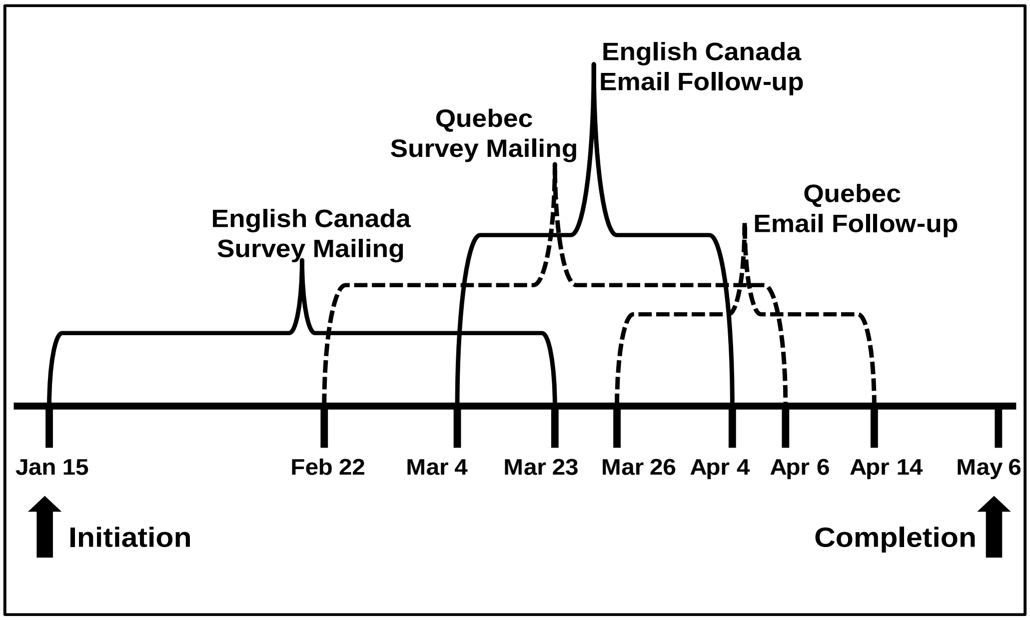
4.2.3 Data Collection:

The questionnaire was initially approved by Ryerson Ethics in March of 2009 and subsequently pilot tested. Based on the pilot test results, additional research and Supervisor guidance, a final survey was developed. The comprehension of the questionnaire was improved by removing ambiguity in terminology where possible and making the questionnaire as simple and concise to use without affecting scale validity (i.e., OCAI). The survey was also reviewed in order to reduce the likelihood of measurement error as a result of method biases. Archival data were not used for this research project and, as a result, the predictor and criterion variables were obtained from the self-reported survey in which anonymity was guaranteed. The final survey was re-submitted to Ryerson Ethics and approved in December 2009.

The standardized questionnaire was mailed to the target population beginning in January of 2010 with subsequent email follow-up to non-responsive firms beginning in March. Questionnaires were mailed to target firms in Quebec at the end of February. The survey was translated into French and mailed to firms in both English and French, consistent with the methodology of Hall and Bagchi-Sen (2002).The questionnaires were addressed to the President and/or CEO of each targeted firm. It is assumed that the President/CEO guides organizational change, reinforces values and has responsibility to establish firm direction (Cameron and Quinn, 1999). Since it was anticipated that there could be difficulties in obtaining primary data from private biotechnology firms, all the data were obtained from the survey.

Data collection continued until early May. The figure below summarizes the timelines of the data collection process.

Figure 4: Data Collection Timeline



A total of 76 surveys were returned by mail or email during the data collection period. A total of 20 firms were removed from the target population due to firm bankruptcy (n=2), failure to deliver surveys by mail (return-to-sender) and email (n=16) and the firm no longer considered themselves to be a biotech organization (n=2). As a result, the 20 firms were removed from the population yielding a total response rate of 76/336 = 23%. The response rate was similar to previous Canadian biotech research utilizing questionnaires (Hall and Bagchi-Sen, 2002; Bagchi-Sen and Scully, 2004). Table 3 provides a regional breakdown of the target population and firm response rates. Overall, the regional response rates for BC, the Prairies and Ontario were fairly similar. Quebec had the lowest response rate and the highest response rate was from the Atlantic region.

Table 3: Survey Response Rate by Region

Regions	N-size	Firms Removed from Population*	N-size (adjusted)†	Surveys Returned (n-size)	Sample (% of n)	Response Rate by Region (%)
BC	72	3	69	16	21%	23%
Prairies[a]	55	1	54	14	18%	26%
Ontario	118	11	107	24	32%	22%
Quebec	78	1	77	12	16%	16%
Atlantic[b]	33	4	29	10	13%	34%
TOTAL	**356**	**20**	**336**	**76**	**100%**	**23%**

[a] Prairies: Alberta, Saskatchewan & Manitoba

[b] Atlantic: Nova Scotia, New Brunswick, Newfoundland & PEI

*Firms removed from population

†N-size (adjusted): 20 firms removed from population

Before data analysis and interpretation, the following two key issues in regards to data quality were addressed;

- Representative sample data
- Response bias

It is assumed that the 23% response rate has generated a sample that is representative of the target population as the entire population was included in the survey, all firms were given an equal chance to participate and all non-responders were followed up by email. Ideally, representation of the data should be validated by contrasting the sample against the population in terms of key attributes such as size, year of establishment or collaborative alliances. However, since these data are not available for all biotech firms in the population as many firms are private, this could not be accomplished. Consequently, it is assumed that the sample contains an equal distribution of biotech firms that reflect the target population.

In terms of response bias it is assumed that firms that chose not to participate did so due to a lack of time to complete the survey (i.e. too busy). This assumption was confirmed through telephone follow-ups with five randomly selected non-responder firms who indicated, as expected, that they were simply; “too busy to take the time to complete the survey”. In addition, wave analysis was performed as surveys were retuned during the data collection period to detect if average responses were changing; no response changes were detected.

4.3 Questionnaire:

Based on the operationalization of the model variables, the questionnaire was designed in four parts;

- Organizational characteristics
- Resource constraints
- The Organizational Culture Assessment Instrument (OCAI)
- Innovation performance

All data was self-reported from one contact in each organization. The in-field questionnaire along with appropriate participant directions is included in Appendix A and B. The following sections provide an overview of the questionnaire.

4.3.1 Firm Characteristics:

Empirical data were collected about each biotechnology organization. The five firm characteristic survey items included in the questionnaire, along with the scales used and their rationale are outlined in Table 4. Biotech sector was included to provide a breakdown of primary organizational focus using segments consistent from previous research methods.

Table 4: Survey Components for Firm Characteristics

Firm Characteristics	Scale	Rationale
Biotech Sector	Industry segment: • Health • Agriculture & Food Processing • Environment • Other (please specify)	A breakdown of primary industry focus using segments consistent from previous research methods
Firm Size (# of employees)	Number	To provide a continuous scale for the number of firm employees
Year of Establishment	Number	To provide a continuous scale (years) from firm establishment to current age
Number of R&D Alliances	Number	To provide a continuous scale that captures firm alliance counts
R&D Intensity (% of total revenues used for R&D)	Percentage	To provide a percentage scale from 0% to 100% consistent with how R&D intensity is reported. If no firm revenues, R&D intensity is reported as 100%

4.3.2 Firm Barriers:

The three firm barriers were assessed through a 7-point Likert scale ranging from strongly disagree (1) to strongly agree (7) for each question. A Likert scale was used to capture the level of agreement or disagreement with the firm barrier statements for venture capital, government spending and human capital.

4.3.3 Organizational Culture Assessment instrument (OCAI):

The OCAI of Cameron and Quinn utilizes a "fixed choice" or ipsative scale - 100 points per each of the six sections with a total of 24 questions. The responses in each section are combined to generate a score for each of the four quadrants of the CVF. Since the results are not independent, the scores generated using the ipsative scale are not appropriate for use in statistical analyses such as correlation, linear regression or LISREL (Quinn and Spreitzer, 1991).

Consequently, since this study required the variables to be independent, a 7-point Likert scale was used for each question. Likert scales allow for independent analysis of each cultural quadrant, the creation of a visual representation of the firm's cultural strengths and weaknesses and more realistic cultural images (Quinn and Spreitzer, 1991). The CVF of culture, reported by Cameron (1978) and Quinn (1988), has been used as both an ipsative and Likert instrument (Quinn and Spreitzer, 1991). The psychometric analysis of CVF cultural instruments support the use of ipsative scales in situations where differences in the four culture types are to be emphasized and use of Likert scales to obtain data in situations where more complex statistical analyses are planned (Quinn and Spreitzer, 1991). There exists evidence for convergent and discriminant validity of the OCAI and it has been used by researchers in a Likert scale format in various research initiatives (Iriana and Buttle, 2006; Boggs, 2004). Furthermore, Cameron and Quinn have done research using both types of response scales and they suggest that the rating scale used by researchers be determined by the statistical tests planned for the data (Cameron and Quinn, 1999).

4.3.4 Innovation Performance:

The innovation measures used to quantify innovation performance (the response variable in this study) were obtained from firm data over the past five years (2005 – 2009). Four survey questions were used to generate an aggregate innovation performance score for each firm (i.e. absolute patent count) based on patent applications and approvals.

5.0 Data Analysis

5.1 Statistical Tests:

The descriptive statistics for the appropriate survey variables (firm characteristics and patents) were generated by SPSS and are displayed in Table 5. In terms of biotech segments, 70% of the firms were involved in health, 12% in agriculture/food processing, 4% environment and 14% other.

Table 5: Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation
SIZE	73	749	1	750	34.90	99.094
YR	74	27	2	29	11.34	7.229
R&D#	66	20	0	20	4.05	4.334
R&D%	71	95	5	100	70.99	36.989
Patents	71	195	0	195	16.68	28.779
Valid N (listwise)	57					

The statistical tests applied to investigate the hypotheses of this research initiative are described below.

H1: *Organizational culture has a significant impact on innovation performance for firms in the Canadian biotechnology industry.*

The method of empirical investigation chosen for H1 was linear regression analysis, ordinary least-squares (OLS) regression. Regression analysis was selected as it allows for the identification and separation of significant effects, the measurement of the size of the effects and for the assessment of effects with a number of variables. The OLS regression equation is listed on the following page and Table 6 provides a description of all the variables used in the empirical analysis.

Equation:

$$PATENTS\ (Y) = \beta_0 + \beta_1 Size + \beta_2 YR + \beta_3 R\&D\# + \beta_4 R\&D\% + \beta_5 VC + \beta_6 GF + \beta_7 HC + \beta_8 CLAN + \beta_9 ADHOC + \beta_{10} MARK + \beta_{11} HIER + ERROR\ TERM$$

Table 6: Variables in the Empirical Model

Abbreviation	Variable	Definition
PATENTS	Innovation performance (dependent variable)	A measure of the aggregate number (output) of firm patent approvals and patent applications over a five year period (2005 – 2009)
Size	Firm size	Defined as the number of employees
YR	Firm age	Age of firm measured in years (year of establishment)
R&D#	Collaborative alliances	Defined as the absolute number of R&D alliances (alliance counts)
R&D%	Absorptive capacity	Defined as the percentage of total revenue allocated toward R&D activity
VC	Venture Capital	Access to venture capital is essential for innovation in your organization. Measured with a 7-point Likert scale
GF	Government Funding	Access to government funds is essential for innovation in your organization. Measured with a 7-point Likert scale
HC	Human Capital	Access to human capital is essential for innovation in your organization. Measured with a 7-point Likert scale
CLAN	Clan Culture	Clan culture as defined by the OCAI. Measured with a 7-point Likert scale
ADHOC	Adhocracy Culture	Adhocracy culture as defined by the OCAI. Measured with a 7-point Likert scale
MARK	Market Culture	Market culture as defined by the OCAI. Measured with a 7-point Likert scale
HIER	Hierarchy Culture	Hierarchy culture as defined by the OCAI. Measured with a 7-point Likert scale

For this empirical analysis, the model was estimated assuming standardized data in SPSS and all models applied mean substitution to address the issue of missing data. The model was derived from a relatively small sample population, n=76. The sample size for analysis would have been reduced by a third to 50 completed surveys from the 76 returned if missing listwise was applied, further reducing the representativeness of the sample and the ability to detect associations. Consequently, it was chosen to use mean substitution to maintain an adequate sample size to detect variable associations. It is important to note that running the model with missing listwise did not produce dramatically different results than using mean substitution. The results for the linear regression equation are reported in Table 7. The adjusted R^2 was 0.145 and none of the covariates reached significance at a *p* value of .05. Two variables trended towards significance; government funding (GF) and absorptive capacity (R&D%) and with a larger sample size significant associations may have occurred.

Table 7: Initial Model Results (Output)

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.341	36.264		.065	.949
	ADHOC	-6.024	6.202	-.175	-.971	.335
	HIER	2.064	3.639	.087	.567	.573
	CLAN	-.795	4.467	-.029	-.178	.859
	MARK	5.679	5.131	.190	1.107	.273
	SIZE	.018	.039	.064	.469	.641
	YR	-.246	.533	-.063	-.462	.646
	GF	-3.516	1.935	-.235	-1.817	.074
	HC	3.076	3.852	.099	.799	.428
	VC	-.077	2.031	-.006	-.038	.970
	R&D%	.227	.116	.291	1.949	.056
	R&D#	-.231	.879	-.034	-.263	.794

a. Dependent Variable: Patents

Additional analyses were performed to improve the regression model:

- The control variables were dropped (i.e. SIZE and Yr) as neither was close to significance and their presence was dragging down the R^2.
- A baseline model was run with no control variables and two firm barrier variables (HC and VC) removed. GF was kept in the baseline model as it trended towards significance in the initial model.

- A number of hierarchical regressions were performed with the four culture constructs added to the baseline model to assess the significance of their impact on R^2.

After performing the additional analysis outlined above a revised linear regression equation was generated.

Equation (Revised):

PATENTS (Y) = $\beta_0 + \beta_1$R&D# + β_2R&D% + β_3GF + β_4MARK + ERROR TERM

The output of the OLS regression model is reported in Table 8. The adjusted R^2 was 0.110 and two of the covariates reached significance; GF and R&D% at a *p* value of .05. The culture type market had the most impact on R^2 in comparison to the other three culture types although it was minor and failed to reach significance similar to the other three culture types. Multicollinearity was assessed for both equations by using SPSS to generate collinearity statistics. Based on tolerance and variation inflation factors (VIF), multicollinearity does not seem to be a concern. For the revised equation all tolerances were greater than 0.9 and VIF values were low (O'Brien, 2007) ranging from 1.0 to 1.1. Endogeneity was not identified in previous biotech research with similar innovation regression models, specifically with patents as the dependent variable (Kang and Lee, 2008; van Moorsel *et al*., 2007). Consequently, there is no reason to expect patents to have an impact on the independent variables of the revised regression equation or for there to be a circular relationship.

Table 8: Revised Model Results (Output)

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	T	Sig.
1	(Constant)	3.492	18.553		.188	.851
	R&D%	.189	.087	.242	2.160	**.034**
	R&D#	-.071	.775	-.010	-.092	.927
	MARK	3.489	3.516	.117	.992	.325
	GF	-3.518	1.760	-.235	-1.999	**.049**

a. Dependent Variable: Patents

H2: *The dominant culture for firms in the Canadian biotechnology industry is the "adhocracy culture" based on the Competing Values Framework.*

An analysis of the highest mean score obtained for each dimension of culture was calculated to identify the dominant cultural type within the sample population. The mean scores for the sample population, both for each dimension and the overall profile type are shown in Table 9. Consistent with previous research using the OCAI, the dominant culture is identified by determining the highest overall mean score for the four cultural types in the population being explored (Berrio, 2003; Boggs, 2004; Cameron and Quinn, 1999: Cameron and Quinn, 2006; Iriana and Buttle, 2006; Igo and Skitmore, 2006; Nummelin, 2007). In this analysis, the highest overall mean score for the population is the adhocracy culture type.

Table 9: Summary of Mean Cultural Profile Score (n=76)

Results	**Culture Types**			
	Clan	Adhocracy	Market	Hierarchy
Overall Profile	**5.27**	**5.51**	**5.02**	**4.12**
Dimensions of Organizational Culture:				
Dominant Characteristics	5.21	5.59	5.54	3.87
Organizational Leadership	5.09	5.71	4.98	5.16
Management of Employees	5.70	4.78	4.81	3.51
Organization Glue	5.82	5.70	4.59	3.66
Strategic Emphases	5.11	5.39	4.82	4.11
Criteria of Success	4.71	5.86	5.38	4.43

Although the OCAI is used to identify a dominant culture and no further statistical tests are required, a paired sample T-Test was run in SPSS to compare the means of the cultural archetypes. The data are presented in Table 10. Overall, there was a significant difference (p<0.05) between adhocracy and market, adhocracy and hierarchy but not in comparison to adhocracy and clan.

Table 10: Comparison of Cultural Mean Scores – Paired Sample T-Test

Pairs	**T**	**Df**	**Sig. (2-tailed)**
Adhocracy – Clan	0.808	5	0.456
Adhocracy – Market	2.781	5	**0.039**
Adhocracy – Hierarchy	6.729	5	**0.001**

H3: *An "adhocracy culture" is associated with higher levels of innovation performance for firms in the Canadian biotechnology industry.*

To test H3, ANOVA was applied to the cultural types and patents (innovation performance) to test for a significantly different mean among the two subsets of data. For the analysis, patents were run as the dependent variable and the culture types were tested individually as factors to determine whether there was significance. For this empirical analysis, SPSS was utilized. All variables were tested using one way ANOVA with missing analysis (i.e. user defined missing values are treated as missing). Consequently, responses missing patent data were dropped from the ANOVA analysis. The results of the ANOVA analysis are reported in Table 11 below.

Table 11: ANOVA Outputs

ANOVA: Patents and Clan

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	1965.093	1	1965.093	2.421	**.124**
Within Groups	56012.456	69	811.775		
Total	57977.549	70			

ANOVA: Patents and Adhocracy

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	1813.303	1	1813.303	2.228	**.140**
Within Groups	56164.246	69	813.975		
Total	57977.549	70			

ANOVA: Patents and Market

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	4366.576	1	4366.576	5.620	**.021**
Within Groups	53610.974	69	776.971		
Total	57977.549	70			

ANOVA: Patents and Hierarchy

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	508.592	1	508.592	.611	**.437**
Within Groups	57468.958	69	832.883		
Total	57977.549	70			

At a *p* value of .05, the market culture was significant (*p*=0.021). As such, based on the data, there is a real difference in patents (innovation performance) between firms with a market culture and firms with a non-market culture. However, adhocracy and clan cultures trended towards an association and an effect may be shown with a larger sample size in future studies. The mean patent number per firm based on cultural type is depicted in Table 12. Overall, the difference between market and the other cultural types is significant, and the impact is positive in direction based on the mean data from the sample population. The mean level of firm patents for the sample population was approximately 17 (please refer to descriptive statistics table).

Table 12: Mean Patent Number per Firm based on Cultural Type

Cultural Type	Number of Firms (n)	Patents (mean number per firm)	ANOVA Significance (p value)
Clan	31	10.3	0.124
Adhocracy	33	10.9	0.140
Market	15	30.3	**0.021**
Hierarchy	5	33.0	0.437

5.2 Findings:

This section reviews the results from the statistical tests outlined previously. Table 13 provides a summary of the hypotheses, findings and the level of support.

H1: *Organizational culture has a significant impact on innovation performance for firms in the Canadian biotechnology industry.*

The sample population was explored with OLS regression to determine associations that may exist between the independent variables and the dependent variable (patents). Following a number of iterations of the model a revised regression equation was generated that balanced maximizing R^2 and identifying variables that had a significant association. The R^2 for the revised equation was slightly lower than the initial equation however, two variables were identified (an organizational aspect and a firm barrier) as having a significant association on the dependent variable. The operationalized variable R&D% (absorptive capacity) was significant at a p value of 0.05 (p=0.034). The beta value for R&D% was 0.189, indicating that greater R&D expenditure was associated with increased innovation performance (patent generation). The second variable to show significance was government funding (GF), significant at a p value of 0.05 (p=0.049). Since the beta value for the GF variable was negative (-3.472), greater innovation performance was shown by firms that disagreed with the statement that access to government funding is essential for innovation.

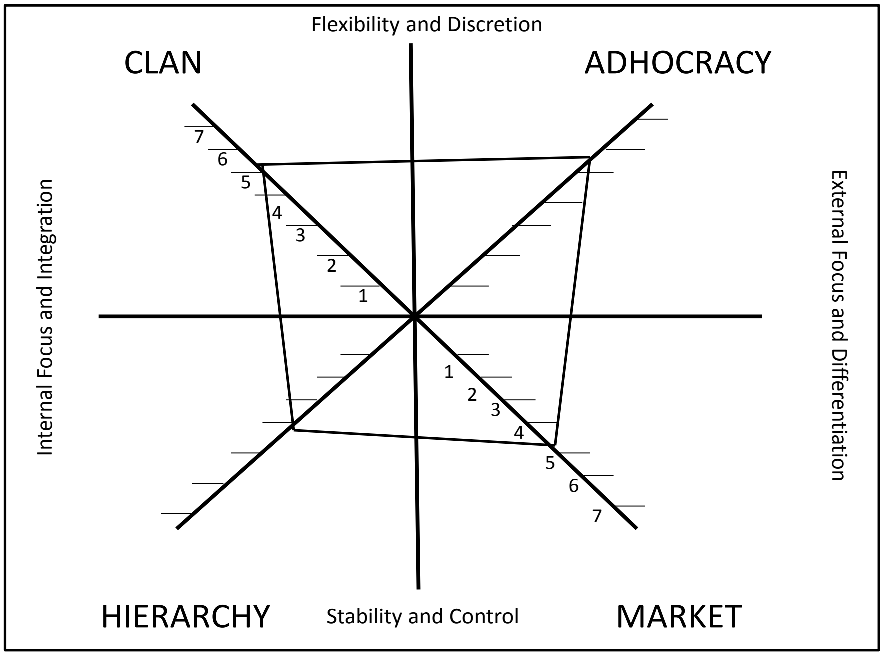
Organizational culture, explored through four distinct cultural archetypes, did not have a significant impact on patents (innovation performance) as theorized. The culture variable “market” added the most power value to the regression model in comparison to the other three cultural types (B=3.489; p= 0.325.)

H2: *The dominant culture for firms in the Canadian biotechnology industry is the "adhocracy culture" based on the Competing Values Framework.*

To determine the dominant cultural type in the sample population the mean scores for the four cultural archetypes (Clan, Market, Adhocracy and Hierarchy) were calculated. The highest mean score (dominant culture) was the adhocracy culture as hypothesized. Comparing the overall mean scores through paired sample T-Tests provided insight into the strength of the culture profile. Overall, the adhocracy culture was significant at a p value of 0.05 in comparison to the market (p=0.039) and hierarchy culture types (p=0.001) but not in comparison to clan culture (p=0.456).

Another aspect to explore based on the data is cultural congruence. Cultural congruence refers to the alignment of various attributes of a firm's culture (Cameron & Quinn, 2006). For example, if the cultural dimensions (i.e. dominant characteristics, organizational leadership, management of employees, organization glue, strategic emphases and criteria of success) all emphasize the same cultural typology for the firm the culture is considered congruent. As such, for this research initiative all the dimensions (attributes) should emphasize an adhocracy culture. Cameron and Quinn (1999 and 2006) have suggested that data from the OCAI can be used to construct spatial maps for all the dimensions and that their plots should be similar to the overall cultural profile (Figure 5) indicating a congruent (aligned) organizational culture. Figure 5 provides a spatial map of the Canadian biotech population's cultural profile, mean scores for the four cultural archetypes, using the Competing Values Framework axis and quadrants.

Figure 5: Spatial Map of Culture Profile



Source: Adapted from Cameron and Quinn, 1999.

Authors have hypothesized that congruent cultures are more characteristic of high performing (effective) firms than incongruent cultures (Cameron and Quinn, 2006; Cameron and Freeman, 1991; Schein, 1984). Upon review of the data (Table 9) the spatial plots for each dimension of the biotechnology sample have a similar profile to that of the overall profile (figure 5 above) with the exception of the dimension of “Management of Employees”. The dimension of “Management of Employees” (adhocracy mean = 4.78) does not appear to be congruent with the other dimensions of culture and the overall adhocracy profile (mean = 5.51). It is important to note that, despite the research that supports the proposed association between congruence of culture or “fit” with high levels of firm effectiveness, empirical support appears to be weak (Cameron and Freeman, 1991). Research by Cameron and Freeman (1991) found no significant difference between congruent and incongruent cultures in terms of organizational effectiveness across multiple organizations (Cameron and Freeman, 1991).

H3: *An "adhocracy culture" is associated with higher levels of innovation performance for firms in the Canadian biotechnology industry.*

To explore differences in innovation performance based on specific cultural types, ANOVA was applied as a statistical test. Although it was hypothesized that firms with an adhocracy culture would generate higher levels of innovation performance (more patents), in fact it was firms with a market culture that showed a significant difference at a p value of 0.05 in patents (p=0.021) in comparison to firms with a non-market culture. The difference between market and the other cultural types was significant, and the impact (mean patent number per firm) was positive in direction based on the sample population. Canadian biotech firms with an adhocracy culture were not associated with higher levels of innovation performance (patent generation).

Table 13: Findings from Hypotheses Testing

Hypotheses	Findings	Support
H1: Organizational culture has a significant impact on innovation performance for firms in the Canadian biotech industry	None of the cultural types had a significant impact on innovation performance	Not supported by the data
H2: The dominant culture for firms in the Canadian biotechnology industry is the "adhocracy culture" based on the Competing Values Framework	The dominant cultural type in the sample population based on the mean score was the adhocracy culture	Supported by the data
H3: An "adhocracy culture" is associated with higher levels of innovation performance for firms in the Canadian biotechnology industry	There is a real difference in patents for market culture versus the three other cultural types (Adhocracy, Clan and Hierarchy)	Not supported by the data

6.0 Discussion

The importance of innovation for biotech firms along with the typical small start-up approach with finite firm resources requires an entrepreneurial managerial approach and, a culture that encourages the organization's founders and/or managers to take greater risks. A "culture of complacency" in terms of entrepreneurship and innovation was identified as the most significant challenge for the future of Canadian biotechnology (Public Policy Forum, 2009). Unfortunately, there is very little information on the impact of culture on innovation performance in the Canadian biotechnology industry, which provided the impetus for this research initiative.

Although previous research in the innovation landscape (Gittelman, 2006; Helfrich *et al*., 2007; Morcillo *et al*, 2007; Teece, 1994) indicated that organizational culture has a significant impact on a firm's ability to innovate this research initiative did not support previous findings. The fundamental conjecture of this thesis, that organizational culture has a significant impact on firm innovation performance in the Canadian biotech industry, was not supported by the data. The research model did not indicate a positive association between any of the cultural archetypes and patent output. A market culture had more of an association on patents in the model than the other three cultural types but it was not significant. However, the "market" culture was positive in terms of its influence on patent generation. It is interesting to note that in the original model equation, adhocracy was not significant and the influence was negative on patent generation.

In this research, innovation performance was defined in terms of patent generation and, although, culture did not have a positive association on patents, the construct may have impact on other measures of innovation performance. For instance, further measures of innovation performance such as trade secrets, market entry for new products and processes, accelerated achievement of internal time lines for product development (milestones) or improved development efficiencies may be impacted by culture. Consequently, future research should explore the impact of culture on additional measures of innovation performance beyond patent outputs.

The Competing Values Framework (CVF) was used as the lens to explore organizational culture for firms in the Canadian biotechnology industry and the Organizational Culture Assessment Instrument (OCAI) was used as the instrument to collect firm level data. It was hypothesized, based on the CVF, that the dominant culture for Canadian biotech firms would be an adhocracy culture. An adhocracy culture would be more appropriate for the competitive environment of biotech firms where innovation, producing unique services and products, flexibility, risk-taking, visionary leadership, creativity and entrepreneurship are cultural traits that are appropriate for the competitive environment that biotech firms function in. The research results confirmed that the dominant culture for Canadian biotech firms is an adhocracy culture indicating that, generally, the culture of Canadian biotech firms, based on the CVF, matches the innovation needs of the industry (i.e. culture and strategy are aligned).

The cultural archetype that generated the highest level of innovation performance was a market culture (significant result with a positive impact on patent numbers) and not an adhocracy culture. It is important to note that the hierarchy culture did have a higher mean patent count versus market but it was not significant due to the small number of firms that had hierarchy cultures and the impact of outliers, broad distribution. A market culture is a competitive, goal-oriented, achievement-based culture with a focus on results and winning which may explain the significant results versus other cultural archetypes.

Overall, based on the results of this research, Canadian biotech firms are dominated by an adhocracy culture but a market culture generates greater innovation performance measured in terms of patents. This creates an area of interesting discussion in terms of the challenges that many Canadian biotech firms face and the business culture in Canada. Although great science is required, the challenge is to get the idea out of the lab and bridge the gulf between discovery and commercialization, the so-called valley of death (Public Policy Forum, 2009). An adhocracy culture may be the appropriate fit for the discovery phase; however; a market culture, with its focus on results, may be more appropriate for generating results (patents) and moving the product and firm forward. This is, of course, conjecture, and would be an interesting area of further research, namely to explore culture at the firm level on a longitudinal perspective rather than a cross-sectional one.

The Canadian Government has been involved in supporting the growth of biotechnology since the 1960s (Bagchi-Sen and Scully, 2004). Consequently, government, as a firm barrier was explored based on the assumption that access to government funds is critical for innovation. However, the results from the research indicated the reverse, as there was a significant association in innovation performance for firms who did not view government funding as critical for innovation in their organization. Hall and Bagchi-Sen (2007) identified government support, defined as funding for R&D and technical training, as key for innovation performance in high intensity R&D firms. Kang and Lee (2008) identified government grants and investment made by the Korean government in biotech as key for driving innovative activity. Although the Canadian and Korean marketplace are not identical, it is clear that governments have a role to play in supporting a key industry, but perhaps the role of government should be more broadly defined in terms of support rather than just providing funding (e.g., grants and direct investment). Government's can provide support beyond direct funding though the creation of an innovative atmosphere, national training programs to create a skilled labour pool, favourable regulations to encourage investment, the rapid development and approval of biotech products, an efficient technology transfer process and the creation of research institutes to stimulate science and the creation of biotech clusters. There is evidence that if a firm wants to achieve a culture of innovation it needs to be supported by government technological policy that complements the organization's efforts to innovate (Morcillo *et al.*, 2007). It is important to note that government funding was not critical for innovation based on the results of this research but it may be critical for commercialization and, as such, this contrast may lead to different results from respondents. Future research should consider exploring more specific measures of government support on innovation outputs.

It was surprising that the construct of collaborative alliances, based on Canadian biotech literature (Baum *et al.,* 2000; Hartel and Woiceshyn, 1996; Hall and Bagchi-Sen, 2002; and van Moorsel *et al.,* 2007) did not have a positive significant impact on innovation performance. In fact, the beta for collaborative alliances was slightly negative. Perhaps a reason for this can be found in New Zealand (Marsh and Oxley, 2005) and Korea (Kang and Lee, 2008) where it was found that domestic alliances had a negative effect on innovative output but that international alliances had a positive impact. International technological diffusion is important for innovation and, as such, future research should explore differences in innovation performance for firms with domestic versus international alliances. It appears that the quality of alliances (linkages) needs to be explored as different linkages may have different degrees of impact on innovation outputs. Utilizing a satisfactory indicator of alliance strength, if available, would help provide insight into the quality of the alliances. In terms of absorptive capacity, consistent with prior biotech research in Canada, New Zealand, Korea and the United States; absorptive capacity, operationalized as R&D%, had a significant impact on innovation performance. This result reinforces that R&D intensive industries such as biotech require a vibrant knowledge base to drive innovation outputs and that absorptive capacity is enhanced by R&D expenditures.

6.1 <u>Limitations:</u>

An important limitation of this research is the use of self-reported responses, which involved drawing assessments of firm culture from only one individual in the firm whose opinions may not truly reflect the culture that exists in the organization (respondent bias). However, self-reported surveys were viewed as the most appropriate instrument to gather quantitative cultural data on firms in the biotech industry and explore their impact on innovation performance. It is assumed that the sample population is representative of the industry but without metrics that can be assessed for all firms and contrast the sample against the population this cannot be validated. Although a number of the survey responses could be obtained from public data (e.g., R&D%, number of employees and collaborative alliances) this would have limited the target population to only public firms, a small population to draw from. Many biotech firms are private and, as such, public information is not available. Consequently, self-reported surveys allowed for the acquisition of primary information from private firms. Previous research in the Canadian biotechnology industry (Bagchi-Sen and Scully, 2004) has identified the difficulty in obtaining primary data from both public and private firms. Ultimately, it is a trade-off: research that has restricted itself to publicly traded firms (George *et al.*, 2002) has cited the exclusion of private firms as a limitation, as it narrows the scope of the study. However, the use of public data may improve the quality of the data by removing the subjectivity of self-reported responses. It is important to note that the target population includes private and public firms and, as a result, the goals and activities may differ between firms with different ownership profiles. The sample size was relatively small and a larger sample size would have allowed for disaggregation of the data and an analysis of biotech firms by public or private ownership.

As identified by Bagchi-Sen and Scully (2004) a key challenge is identifying the firms to be surveyed. Although there are a number of databases to draw a sample population from, data may be missing or inaccurate, which can lead to inconsistencies in the sample population from one study to another and possible sample bias. The difficulty in identifying the biotech firms to survey will be a challenge for all research performed in the biotech landscape. As indicated earlier, the operationalization of collaborative alliances should be broader than just absolute number counts in order to take into account the strength (value) of firm linkages and their impact on innovation performance.

For this research initiative culture was explored at the firm level; however, organizational culture can exist at the sub-unit level in work teams, product groups or at hierarchical level. Although culture was not shown to have an impact on patents at the firm level there may be an impact of culture within the organization or even at a spatial level as regional differences in the Canadian biotech landscape may be associated with a unique culture. Future research should explore the possibility of cultural differences within biotech organizations and/or on a regional basis considering the three core geographical areas for Canadian biotech (i.e. Vancouver, Toronto and Montreal).

As outlined in the literature review innovation performance has not been clearly defined and, as such, there exists a range of measures used to operationalize the construct. For this research initiative innovation performance was operationalized as the sum of a firm's patent applications and approvals, another measure may have produced different results. In addition, the research model, although developed based on the existing literature was not highly predictive of patent output. Further research should investigate the operationalization of the model's variables and the addition of other explanatory variables.

The competing values framework and the OCAI were utilized for this research; however, there are additional frameworks and instruments (e.g., Cultural Assets Profiles, Organizational Profile Questionnaire and Organizational Culture Inventory) that use both quantitative and qualitative techniques for investigating organizational culture that could be utilized for future research. Considering the importance of culture in the Canadian biotechnology arena and the limited research that has been performed, further research applying different theoretical frameworks and appropriate instruments should be considered. The instrument used in the research, the OCAI, was utilized as a Likert scale to allow for regression analysis, a procedure not possible if an ipsative rating scale was used. However, one of the limits of using a Likert scale for the OCAI is that respondents may rate all questions high or low for a specific section, resulting in less differentiation versus an ipsative scale that forces the respondents to choose generating greater differentiation. Consequently, using a Likert scale may not have provided significant differentiation in firm culture data and may have limited the operationalization of the construct. In addition, although the OCAI has been used extensively, a number of the questions in the instrument may lead to a “pro-innovation bias” in the responses and could skew the results in favour of innovation. Finally, it is important to note that biotech is a dynamic industry and, as such, the associations between variables may only represent one point in time.

7.0 Conclusion

This is the only known study that has explored the impact of culture on innovation performance in the Canadian biotech industry. Furthermore, according to the literature, the impact of culture on innovation performance in biotech has not been extensively explored. Overall, based on the results of this research, organizational culture did not have a significant impact on innovation performance, defined in terms of patents, for firms in the Canadian biotechnology industry. However, as an explorative study, this research initiative has identified a dominant cultural type (adhocracy culture) present in the Canadian biotech industry based on the Competing Values Framework of Cameron and Quinn (1999). In addition, and interestingly, biotech firms with a market culture generated more patents (higher innovation performance) than the other three cultural archetypes of adhocracy, clan and hierarchy. This contrast raises some interesting issues that should be explored in terms of firm culture and appear to reinforce the need to balance great science with strong management skills that will efficiently move new products from the lab to the market.

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Appendix A: Canadian Biotechnology Survey – English Canada

January 4th, 2010

Dear Sir/Madam:

RE: Biotechnology Industry Survey – Master's Thesis

I am currently working on my thesis as part of my Master of Management Science (MMSc) program at Ryerson University. The topic of my research is;

"An exploration of the impact of organizational culture on innovation performance in the Canadian biotechnology industry"

In order to examine this quantitative research initiative I have included a survey, which once completed, will provide data to explore the above topic.

If you could please take approximately 12 minutes to complete the enclosed survey and return it to my attention at, **16 Underhill Crescent, Aurora, ON, L4G 5S2**; it would be greatly appreciated. Once the survey is complete, your results will be added to all the data that will be collected from participating organizations. Any feedback or comments you may have are welcome.

My phone number and email address are listed below; please feel free to contact me if you have any questions. In addition, the contact information for my thesis supervisor is at the bottom of the page.

Sincerely,

Max Johnson
16 Underhill Crescent
Aurora, ON
L4G 5S2
Phone: (905) 726-2986
Email: maxwell.johnson@ryerson.ca

Thesis Supervisor:
Dave Valliere
Ted Rogers School of Business Management
Ryerson University
Phone: (416) 979-5000, ext. 7603
Email: valliere@ryerson.ca

Canadian Biotechnology Survey

Consent & Confidentiality:

Your participation is greatly appreciated.

It is important to note that the completion of the survey implies consent to use the data for the study. The confidentiality of the data will be secured, both in terms of the individual completing the survey and the specific company information provided. The participation in this study is voluntary and that the decision to participate, or not, will have no effect on one's employment or relationships with Ryerson University. In addition, one may choose to do the survey and not answer a particular question if one wishes.

As outlined on the previous page, the topic of the research is;

"An exploration of the impact of organizational culture on innovation performance in the Canadian biotechnology industry"

The attached survey will provide the necessary data to allow the opportunity to examine this quantitative research initiative. It is anticipated that the survey will take 12 minutes to complete.

Name: ______________________________

Position: ______________________________

Company: ______________________________

Please Note: The Survey is double sided

Survey

Instructions:
The survey is divided into **four (4) parts**. It is estimated that the survey will take 12 minutes to complete. Each section has specific instructions.

Part 1: Organizational Characteristics
Please check (√) or provide the required information for each corresponding firm characteristic listed below.

Firm Characteristics	Survey Item
Biotech Sector	Health ________ Agriculture & Food processing ________ Environment ________ Other (please specify) ________
Firm Size (# of employees)	Number (please specify) _________
Year of Establishment	Year _________
Number of R&D Alliances	Number (please specify) _________
R&D Intensity (% of total revenues used for R&D)	Percentage (please specify) _________ % **Note:** If no revenues, please report 100%

Part 2: Resource Constraints
On a scale of (1) strongly disagree to (7) strongly agree; please rate your agreement with the following statements and **circle** the corresponding number.

Survey Item
Access to **venture capital** is critical for innovation in your organization Strongly Disagree ... Strongly Agree 1 2 3 4 5 6 7
Access to **government funding** is critical for innovation in your organization Strongly Disagree ... Strongly Agree 1 2 3 4 5 6 7
Access to **human capital** (scientific and commercial expertise) is critical for innovation in your organization Strongly Disagree ... Strongly Agree 1 2 3 4 5 6 7

Part 3: Organizational Culture Assessment Instrument (OCAI)

The survey items below are measured through a 7-point Likert scale that ranges from strongly disagree (1) to strongly agree (7). Please **circle** the corresponding number.

1. Dominant Characteristics	
A	The organization is a very personal place. It is like an extended family. People seem to share a lot of themselves. Strongly Disagree … Strongly Agree 1 2 3 4 5 6 7
B	The organization is a very dynamic and entrepreneurial place. People are willing to stick their necks out and take risks. Strongly Disagree … Strongly Agree 1 2 3 4 5 6 7
C	The organization is very results orientated. A major concern is with getting the job done. People are very competitive and achievement-oriented. Strongly Disagree … Strongly Agree 1 2 3 4 5 6 7
D	The organization is a very controlled and structured place. Formal procedures generally govern what people do. Strongly Disagree … Strongly Agree 1 2 3 4 5 6 7
2. Organizational Leadership	
A	The leadership in the organization is generally considered to exemplify mentoring, facilitating, or nurturing. Strongly Disagree … Strongly Agree 1 2 3 4 5 6 7
B	The leadership in the organization is generally considered to exemplify entrepreneurship, innovation, or risk taking. Strongly Disagree … Strongly Agree 1 2 3 4 5 6 7

C	The leadership in the organization is generally considered to exemplify a no-nonsense, aggressive, results orientated, focus. Strongly Disagree ... Strongly Agree 1 2 3 4 5 6 7
D	The leadership in the organization is generally considered to exemplify coordinating, organizing, or smooth-running efficiency. Strongly Disagree ... Strongly Agree 1 2 3 4 5 6 7
3. Management of Employees	
A	The management style in the organization is characterized by teamwork, consensus, and participation. Strongly Disagree ... Strongly Agree 1 2 3 4 5 6 7
B	The management style in the organization is characterized by individual risk-taking, innovation, freedom, and uniqueness. Strongly Disagree ... Strongly Agree 1 2 3 4 5 6 7
C	The management style in the organization is characterized by hard-driving competitiveness, high demands, and achievement. Strongly Disagree ... Strongly Agree 1 2 3 4 5 6 7
D	The management style in the organization is characterized by security of employment, conformity, predictability, and stability in relationships. Strongly Disagree ... Strongly Agree 1 2 3 4 5 6 7
4. Organizational Glue	
A	The glue that holds the organization together is loyalty and mutual trust. Commitment to this organization runs high. Strongly Disagree ... Strongly Agree 1 2 3 4 5 6 7

B	The glue that holds the organization together is commitment to innovation and development. There is an emphasis on being on the cutting edge. Strongly Disagree ... Strongly Agree 1 2 3 4 5 6 7
C	The glue that holds the organization together is the emphasis on achievement and goal accomplishment. Aggressiveness and winning are common themes. Strongly Disagree ... Strongly Agree 1 2 3 4 5 6 7
D	The glue that holds the organization together is formal rules and policies. Maintaining a smooth-running organization is important. Strongly Disagree ... Strongly Agree 1 2 3 4 5 6 7
5. Strategic Emphases	
A	The organization emphasizes human development. High trust, openness, and participation persist. Strongly Disagree ... Strongly Agree 1 2 3 4 5 6 7
B	The organization emphasizes acquiring new resources and creating new challenges. Trying new things and prospecting for opportunities are valued. Strongly Disagree ... Strongly Agree 1 2 3 4 5 6 7
C	The organization emphasizes competitive actions and achievement. Hitting stretch targets and winning in the marketplace are dominant. Strongly Disagree ... Strongly Agree 1 2 3 4 5 6 7
D	The organization emphasizes permanence and stability. Efficiency, control and smooth operations are important. Strongly Disagree ... Strongly Agree 1 2 3 4 5 6 7

6. Criteria of Success	
A	The organization defines success on the basis of the development of human resources, teamwork, employee commitment, and concern for people. Strongly Disagree ... Strongly Agree 1 2 3 4 5 6 7
B	The organization defines success on the basis of having the most unique or newest products. It is a product leader and innovator. Strongly Disagree ... Strongly Agree 1 2 3 4 5 6 7
C	The organization defines success on the basis of winning in the marketplace and outpacing the competition. Competitive market leadership is key. Strongly Disagree ... Strongly Agree 1 2 3 4 5 6 7
D	The organization defines success on the basis of efficiency. Dependable delivery, smooth scheduling, and low-cost production are critical. Strongly Disagree ... Strongly Agree 1 2 3 4 5 6 7

Part 4: Innovation Performance

For your organization, please indicate the number of patent applications and approvals over the past five years (2005 through 2009) for the corresponding innovation measure in the table below. **Please note;** in order to avoid double counting patents, if the same patent is applied for and approved during the 2005 through 2009 time period, only the approved patent should be counted.

Innovation Measures	Number of Company Applications/Approvals in the last 5-Years (2005 – 2009)
1. United Sates Patent Applications	
2. United States Patent Approvals	
3. International Patent Applications (Submitted to Patent Cooperation Treaty)	
4. International Patent Approvals	

- Thank you for completing the survey -

Appendix B: Canadian Biotechnology Survey – Quebec

Sondage sur l'industrie des biotechnologies canadienne
Version en français

Le 4 janvier 2010

Monsieur/Madame :

OBJET : Sondage sur l'industrie des biotechnologies – Mémoire de maîtrise

Je travaille actuellement sur mon mémoire de maîtrise en science de la gestion (MMSc) à l'Université Ryerson. Le sujet de mon travail est le suivant :

« Conséquences de la culture d'entreprise sur le rendement des innovations dans l'industrie des biotechnologies canadienne »

Afin d'examiner cette démarche de recherche quantitative, j'ai inclus un sondage qui, une fois terminé, me fournira des données utiles pour approfondir le sujet du mémoire.

Ce sondage devrait prendre environ 12 minutes de votre temps. Je vous serais très reconnaissant de bien vouloir remplir un des questionnaires ci-joint (celui en français ou en anglais, selon votre préférence) et de le retourner à mes soins, à l'adresse suivante : **16 Underhill Crescent, Aurora, ON, L4G 5S2**. Une fois le sondage terminé, vos résultats viendront s'ajouter à toutes les données recueillies auprès des entreprises participantes. Je vous invite à ajouter des commentaires si vous le désirez.

N'hésitez pas à me contacter si vous avez des questions. Vous trouverez mon numéro de téléphone et mon adresse de courriel ci-dessous. J'ai également indiqué les coordonnées de mon directeur de mémoire en bas de la page.

Veuillez agréer mes salutations distinguées.

Max Johnson
16 Underhill Crescent
Aurora, ON L4G 5S2
Téléphone : (905) 726-2986
Courriel : maxwell.johnson@ryerson.ca

Directeur de mémoire :
Dave Valliere
Ted Rogers School of Business Management
Ryerson University
Téléphone : (416) 979-5000, poste 7603
Courriel : valliere@ryerson.ca

Sondage sur l'industrie des biotechnologies canadienne

Consentement et confidentialité :

Votre participation est très appréciée.

Il est important de préciser que votre participation à ce sondage signifie que vous donnez votre consentement à l'utilisation des données pour l'étude. La confidentialité des données est garantie, aussi bien pour la personne qui remplit le sondage que pour l'entreprise participante. La participation à cette étude est volontaire et la décision d'y participer ou non n'aura pas d'effet sur votre emploi ou vos relations avec l'Université Ryerson. Les personnes qui remplissent le sondage sont libres de ne pas répondre à toutes les questions.

Comme cela est indiqué à la page précédente, le sujet de la recherche est le suivant :

« Conséquences de la culture d'entreprise sur le rendement des innovations dans l'industrie des biotechnologies canadienne »

Le sondage ci-joint me fournira des données utiles pour approfondir le sujet du mémoire. Ce sondage devrait prendre environ 12 minutes de votre temps.

Nom : ____

Poste : ____

Entreprise : ____

Le sondage est imprimé recto verso

Sondage

Directives :
Le sondage est divisé en **quatre (4) parties** et devrait prendre environ 12 minutes de votre temps. Chaque section s'accompagne de directives précises.

1ère partie : Caractéristiques organisationnelles

Cochez la réponse correspondante (√) à votre entreprise ou entrez les renseignements demandés pour chaque caractéristique ci-dessous.

Caractéristiques de l'entreprise	Question du sondage
Secteur des biotechnologies	Santé _________ Agro-alimentaire _________ Environnement _________ Autre (précisez SVP) _________
Taille (nombre d'employés)	Nombre (précisez SVP) _________
Année de création	Année _________
Partenariats de R. et D.	Nombre (précisez SVP) _________
Intensité des activités de R. et D. (% du chiffre d'affaires consacré aux activités de R. et D.)	Pourcentage (précisez SVP) _________ % **N.B. :** En l'absence de chiffre d'affaires, indiquez 100 %

2e partie : Restrictions de ressources

Sur une échelle allant de 1 à 7 (1 correspondant à « tout à fait d'accord » et 7 à « pas du tout d'accord », indiquez ce que vous pensez des affirmations suivantes en **entourant** le chiffre correspondant à votre réponse.

Question du sondage
L'accès au **capital-risque** est essentiel à l'innovation dans votre entreprise Pas du tout d'accord — Tout à fait d'accord 1 2 3 4 5 6 7
L'accès aux **subventions publiques** est essentiel à l'innovation dans votre entreprise Pas du tout d'accord — Tout à fait d'accord 1 2 3 4 5 6 7
L'accès au **capital humain** (expertise scientifique et commerciale) est essentiel à l'innovation dans votre entreprise Pas du tout d'accord — Tout à fait d'accord 1 2 3 4 5 6 7

3e partie : Outil d'évaluation de la culture d'entreprise (OCAI)

Les questions du sondage ci-dessous sont évaluées selon une échelle de Likert à 7 points allant de « Pas du tout d'accord (1) » à « Tout à fait d'accord (7) ». Veuillez **entourer** le chiffre correspondant à votre réponse.

1. Principales caractéristiques	
A	L'entreprise est un lieu très personnel. L'entreprise est comme une deuxième famille. Les gens semblent beaucoup partager. Pas du tout d'accord — Tout à fait d'accord 1 2 3 4 5 6 7
B	L'entreprise est un lieu très dynamique et propice à l'esprit d'initiative. Les gens n'hésitent pas à s'impliquer en prenant des risques. Pas du tout d'accord — Tout à fait d'accord 1 2 3 4 5 6 7
C	La gestion de l'entreprise est axée sur les résultats. La seule préoccupation des employés est d'accomplir leur mission. Les gens sont très compétitifs et concentrés sur les objectifs à atteindre. Pas du tout d'accord — Tout à fait d'accord 1 2 3 4 5 6 7
D	L'entreprise est un lieu contrôlé et structuré. Toutes les activités sont régies par des procédures formelles. Pas du tout d'accord — Tout à fait d'accord 1 2 3 4 5 6 7
2. Direction	
A	On considère généralement que la direction de l'entreprise incarne le mentorat, la facilitation ou la stimulation des employés. Pas du tout d'accord — Tout à fait d'accord 1 2 3 4 5 6 7
B	On considère généralement que la direction de l'entreprise incarne l'esprit d'initiative, l'innovation ou la prise de risque. Pas du tout d'accord — Tout à fait d'accord 1 2 3 4 5 6 7

C	On considère généralement que la direction de l’entreprise incarne une culture directe, agressive, et axée sur les résultats. Pas du tout d’accord … Tout à fait d’accord 1 2 3 4 5 6 7
D	On considère généralement que la direction de l’entreprise incarne des qualités de coordination, d’organisation ou d’efficacité. Pas du tout d’accord … Tout à fait d’accord 1 2 3 4 5 6 7
3. Gestion des employés	
A	Le style de gestion au sein de l’entreprise se caractérise par le travail d’équipe, le consensus, et la participation. Pas du tout d’accord … Tout à fait d’accord 1 2 3 4 5 6 7
B	Le style de gestion au sein de l’entreprise se caractérise par la prise de risque individuelle, l’innovation, la liberté et l’individualité. Pas du tout d’accord … Tout à fait d’accord 1 2 3 4 5 6 7
C	Le style de gestion au sein de l’entreprise se caractérise par un esprit de concurrence intense, des exigences élevées, et l’efficacité. Pas du tout d’accord … Tout à fait d’accord 1 2 3 4 5 6 7
D	Le style de gestion au sein de l’entreprise se caractérise par la sécurité d’emploi, la conformité, la prévisibilité et la stabilité des relations. Pas du tout d’accord … Tout à fait d’accord 1 2 3 4 5 6 7
4. Ciment organisationnel	
A	Le ciment qui soude l’entreprise est la fidélité et la confiance mutuelle. L’engagement au sein de l’entreprise est élevé. Pas du tout d’accord … Tout à fait d’accord 1 2 3 4 5 6 7

B	Le ciment qui soude l'entreprise est l'engagement envers l'innovation et l'expansion. L'entreprise s'efforce d'être à l'avant-garde. Pas du tout d'accord — Tout à fait d'accord 1 2 3 4 5 6 7
C	Le ciment qui soude l'entreprise est l'accent sur les résultats et la réalisation des objectifs. L'agressivité et les succès sont des thèmes courants. Pas du tout d'accord — Tout à fait d'accord 1 2 3 4 5 6 7
D	Le ciment qui soude l'entreprise repose sur les politiques et les règles formelles. Il est important de maintenir le bon fonctionnement de l'entreprise. Pas du tout d'accord — Tout à fait d'accord 1 2 3 4 5 6 7
5. Priorité stratégique	
A	L'entreprise met la priorité sur le perfectionnement des ressources humaines pour favoriser la confiance, l'esprit d'ouverture et la participation. Pas du tout d'accord — Tout à fait d'accord 1 2 3 4 5 6 7
B	L'entreprise met la priorité sur l'acquisition de nouvelles ressources et la création de nouveaux défis. L'expérimentation et l'exploration de nouvelles voies sont valorisées. Pas du tout d'accord — Tout à fait d'accord 1 2 3 4 5 6 7
C	L'entreprise met la priorité sur les actions et les réalisations concurrentielles. La réalisation d'objectifs et les succès sur le marché sont prédominants. Pas du tout d'accord — Tout à fait d'accord 1 2 3 4 5 6 7
D	L'entreprise met la priorité sur la permanence et la stabilité. L'efficacité, le contrôle et le bon fonctionnement sont importants. Pas du tout d'accord — Tout à fait d'accord 1 2 3 4 5 6 7

6. Critères de réussite	
A	L'entreprise définit la réussite en fonction du perfectionnement des ressources humaines, du travail d'équipe, de l'engagement des employés et de son souci des gens. Pas du tout d'accord … Tout à fait d'accord 1 2 3 4 5 6 7
B	L'entreprise définit la réussite en fonction de l'originalité et du caractère innovant de ses produits. C'est un chef de file du marché à la pointe de l'innovation. Pas du tout d'accord … Tout à fait d'accord 1 2 3 4 5 6 7
C	L'entreprise définit la réussite en fonction des succès obtenus sur le marché et par rapport à la concurrence. L'avantage concurrentiel est fondamental. Pas du tout d'accord … Tout à fait d'accord 1 2 3 4 5 6 7
D	L'entreprise définit la réussite en fonction de l'efficacité. La fiabilité des livraisons, le respect des délais et la production à bas coût sont des critères fondamentaux. Pas du tout d'accord … Tout à fait d'accord 1 2 3 4 5 6 7

4e partie : Rendement des innovations

Veuillez indiquer le nombre de demandes de brevets déposées et acceptées pour votre entreprise au cours des cinq dernières années (de 2005 à 2009) pour les mesures d'innovation correspondante dans le tableau ci-dessous. **Attention :** pour éviter de compter deux fois le même brevet, si la demande de brevet est déposée et acceptée pendant la période allant de 2005 à 2009, seule la demande de brevet acceptée doit être compté.

Mesures d'innovation	**Nombre de demandes de brevets déposées/acceptées au cours des 5 dernières années (2005 – 2009)**
1. Demandes de brevet déposées aux Etats-Unis	
2. Demandes de brevets acceptées aux Etats-Unis	
3. Demandes internationales de brevets soumises par la voie PCT (Patent Cooperation Treaty).	
4. Demandes internationales de brevets acceptées	

- Merci de votre coopération –