Open Innovation – The Case of Canadian Nanotechnology Industry

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Abstract
Open business models are one of the business models that high-tech industries are applying in their firms. In this research Canadian nanotechnology industry will be focused in order to find the most frequent open innovation practices and compare English and French provinces of Canada. Since, Europe is one of the pioneers of this type of business model; Canada will be compared with Europe to find the differences. Descriptive statistical analysis is performed on a dataset which was gathered from an online survey.

Keywords – **Business Model, Open Innovation, Nanotechnology, Survey Data Analysis, Canada**

1 INTRODUCTION

Nanotechnology can address key Canadian economic and social challenges relating to mining and agribusiness; health and medicine; energy and environment; advanced materials and manufacturing; electronics; and information and communication technologies.

According to the report which was published in 2013 [Sargent Jr 2013]; the global governmental nanotechnology spending for top ten countries is shown in figure 1. Canada is among the top ten countries.
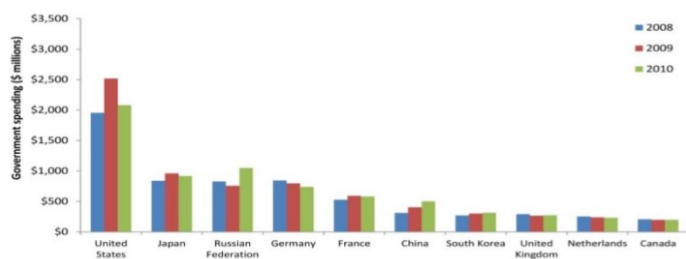

Figure 1. Global Government nanotechnology spending for top ten countries, 2008-2010 [Xue 2011]

Canada is not in the list of the corporate nanotechnology spending for top ten countries. Figure 2.
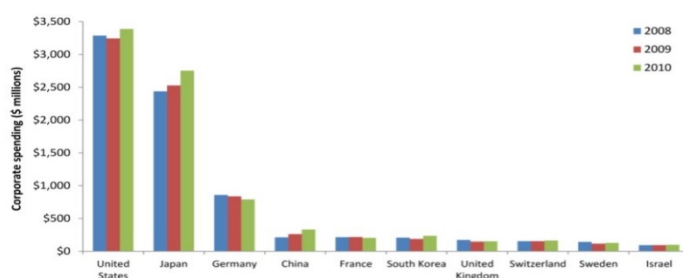

Figure 2. Corporate nanotechnology spending for top ten countries, 2008-2010 [Xue 2011]

Canada is within the list of top five countries that venture capital spending in nanotechnology. Figure 3.
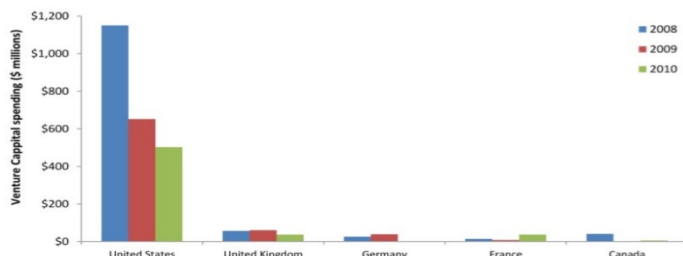
Moreover, figure 4, shows the percentage of science publications that are nanotech.
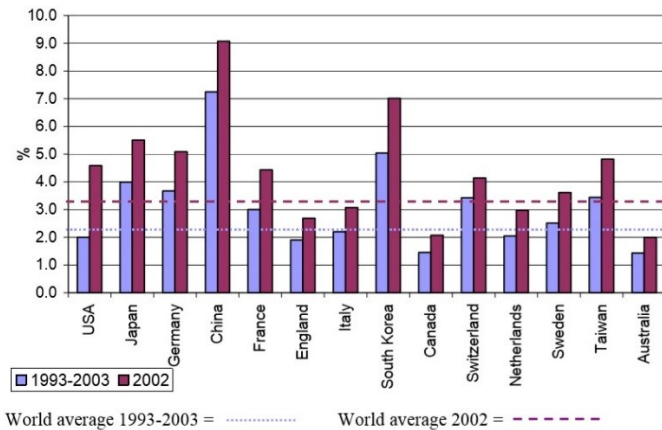

Figure 4 – Percentage of science publications that are nanotech for selected countries or regions, 1993-2003 [Warris 2004]

Base on the presented information, in this research scientists who are working in nanotechnology industry from Canada, Netherlands, France, United Kingdom, Germany and Belgium was contacted and the analysis conducted on the data gathered from these high-tech countries in nanotechnology.

Open business model is one type of business model which is used in high-tech industries and could increase the performance of firms. There are different practices for applying open innovation in a firm which will be discussed in details in this research.

The rest of this article is organized as follows: In part 2, the concept of open innovation and types of open innovation and open innovation practices are discussed. In part 3, titled as methodology describes the method has been used for this study and talks about the data gathering process. Part 4 is dedicated to four categories of results have been reached in this study. Finally, a conclusion from these results is discussed.

2 LITERATURE REVIEW

This section reviews literatures of Open Innovation concept.

2.1. Business Model

A business model shows how an organization creates, delivers, and captures value [Osterwalder, Pigneur 2010]. Open innovation in one of different patterns of business models.

2.2. Open Innovation

Before defining the concept of open innovation, the concept of closed innovation will be discussed: If a company has a closed business model, the following would be their characteristics: the smart people in the field work for them. To profit from R&D, they must discover the product first, develop it and ship it themselves. If they discover it themselves, they will get it to the market first. If they create the most and the best ideas in the industry, they will win. They should control their intellectual property (IP), so that other competitors do not profit from their ideas [Osterwalder,

Pigneur 2010].

The concept of open innovation has been defined by Henry Chesbrough in 2003. By googling the word "Open Innovation" there will be about 483 million links available and there is an increase in books and publication in this area. Based on [Chesbrough and Bogers, 2014] the definition of Open Innovation is "*a distributed innovation process based on purposively managed knowledge flows across organization boundaries, using pecuniary and non-pecuniary mechanism in line with each organization's business model.*" These flows could be through an organization, from an organization or both.

The idea that most smart people work for someone else is called Joy's law [Lakhani, Panetta 2007]. Companies use the external knowledge and ideas of other companies in their own business and let the other companies use their internal unused ideas and technologies (Chesbrough 2003).

Table 1. Open versus Closed [Osterwalder, Pigneur 2010]

	Smart People		R&D - Ideas		Knowledge		Innovation – IP	
	Inside Firm	Outside Firm	Internal	External	Create	Transfer	Control	Share / Buy
Open	✓	✓	✓	✓	✓	✓	-	✓
Closed	✓	-	✓	-	✓	-	✓	-

Although, table 1 mentioned some features of open innovation models versus closed innovation models, researchers mentioned that openness is not a binary classification of open versus closed [Chesbrough 2003]

Chesbrough mentioned some reasons of having the change from closed innovation to open innovation and he called them erosion factors.

These factors are increase mobility of workers, more capable universities, declining US hegemony, growing access of start-up firms to venture capital [Chesbrough 2003] and rise of internet [Chesbrough, Bogers 2014].

2.2.1. Types of Open Innovation

Open innovation business model is categorized into three different types. The first type of open innovation practices is inside-out (outbound) practices, which allows firms to sell or transfer unused and unutilized ideas and technologies to other firms. The second type is outside-in (inbound) practices, which involves opening up company's own innovation to other companies for any kinds of contribution [Chesbrough, 2003]. The outside-in type of practices was introduced by Cohen and Levinthal in 1990 [Cohen & Levinthal, 1990].The last type of practices is combined coupled type [Gassmann and Enkel, 2004]. Also, Dahlandera and Gann categorized them into two different types of pecuniary and non-pecuniary [Dahlander and Gann 2010].

2.2.2. Open Innovation Practices

There are several practices which companies are applying in firms to have higher degree of openness and performance in their firms. [Chesbrough and Bogers 2014]. Based on different business plans, firms will use some of the practices of open innovation. Practices related to inbound practices are, scouting, in licensing IP,

university research programs, funding start-up companies in one's industry, or collaborating with intermediaries, suppliers and customers, and utilizing nondisclosure agreements, crowdsourcing, competitions and tournaments, communities and spin-ins or spin-back [Chesbrough and Bogers, 2014]. The outbound practices are such as, out licensing IP and technology, donating IP and technology, spin-outs, corporate venture capital, corporate incubators, joint ventures and alliances. Practices which are used for coupled openness are such as, joint invention and commercialization activities [Bogers, 2011], [Bekkers et al., 2012].

2.2.3. Recent studies

Laursen et al. designed a survey named U.K. Innovation Survey which is based on European Community Innovation Survey (CIS). They sent the survey to 19602 business units in the United Kingdom in two different steps in 2001 and their response rate was 41.7 percent. They used a subsample of 2707 manufacturing firms for this research. Their research findings are saying that using more number of sources will cause to be more open than the other firms which are not using. [Laursen and Salter, 2004]. Searching is curvilinearly related to performance. However, oversearch would result negative effects on innovative performance (Laursen and Salter, 2006).

Chesbrough et al. found that open innovation is just for high-technology industries while the concept is in an early stage in other industries. Also, participants did not mention that use of open innovation is not primarily applied in their companies to reduce cost or outsourcing of the R&D functions [Chesbrough, Crowther 2006].

Han van der Meer conducted a survey on Dutch companies named as Dutch National Innovation Survey. They worked on a sample consists of 814 questionnaire responses and 28 interviews. They found that principal of open innovation (its culture and importing mechanisms) is successfully accepted in innovative Dutch companies. [Van der Meer 2007].

Vareska van de Vrande et al. studied on a sample of 605 innovative firms in Netherlands. They used a computer-assisted telephone interviewing. They found that most of the studies are about high-tech, multinational enterprises. They focused on applying open innovation practices on SMEs. They found that medium sized firms are more involved in applying open innovation practices than small sized firms. The reason that SMEs are involved in open innovation is mostly because of meeting customer demands or keeping up with competitors [Van de Vrande, 2009].

In 2013, Chesbrough and Brunswicker, designed a survey and asked about the main practices, challenges, outcomes, partners, etc. of large firms in United States. [Chesbrough and Brunswicker, 2013].

In 2015, researchers studied the open innovation practices in SMEs of part of Pakistan. They studied Jewelers and beauty industry with a questionnaire on a sample of 15 business shop who are working in this area. They found that most of the SMEs in this industry apply open innovation practices and use different external resources [Khan, Khan et al. 2015].

In this research, nanotechnology industry of Canadian firms will be analyzed and it will be compared with European firms.

3. METHODOLOGY

Based on the nanotechnology articles database, the contact information of the non-academic authors' affiliation has been gathered. A questionnaire has been designed based on Open Innovation concept and was sent to these firms. The descriptive statistical analysis has been done on the responses.

3.2. Data

The open innovation practices data of this research has been gathered by sending the online questionnaire to the targeted recipients from Canada, Netherlands, France, United Kingdom, Germany and Belgium. The research team has contacted these scientists and asked them to participate in the online survey. The figure 5 describes the flowchart of the questionnaire. Participants are asked to mention about their firm's size by answering to two questions about number of employees and average annual revenue. Then, they are asked to specify their frequency of applying open innovation practices, inside-out and outside-in, in a Likert scale (Always, Sometimes, Rarely). Finally they have to mention their performance change in a Likert scale (Increased, Remained the same, Decreased).
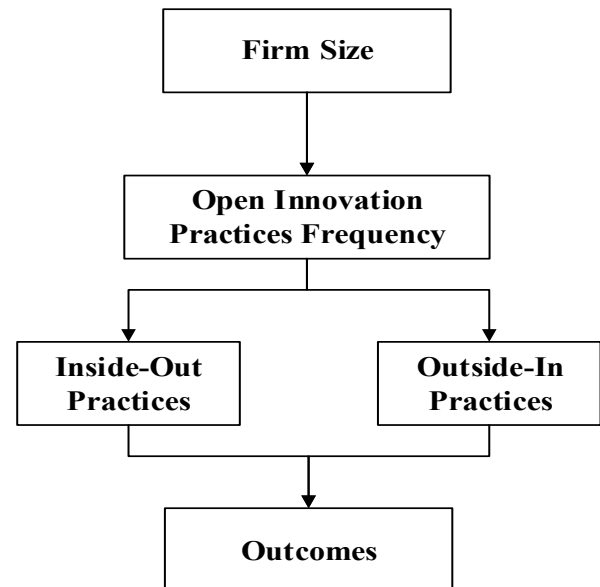

Figure 5. Questionnaire structure

Open innovation practices which are focused in this research are presented in table 2.

Table 2. Open Innovation practices

Outside-In Pecuniary	Inside-Out Pecuniary
Buying a License (P1)	Joint-Venture Agreement (P8)
Contract with other companies for R&D services (P2)	Sell New Knowledge developed in R&D to another company (P9)
Buying any innovative ideas from start-up companies (P3)	Participating in a business incubator programs (P10)
Consulting with any specialized Open Innovation companies (P5)	Selling R&D market ready by-product (P11)
Collaborating with students in a research agreement with a university (P6)	Selling license of innovations (P12)
Assigning a research fund to an academic institute (P7)	

Outside-In Non-Pecuniary	Inside-Out Non-Pecuniary
Crowdsourcing (P4)	Providing innovation for standardization organization (P13)
	Donating innovation / knowledge to any non-profit organization (P14)

95 Canadian firms and 96 European firms are participated in this survey. Table 3 shows the distribution of these participants based on their countries.

Table 3. Survey participants' countries

Country			
		Frequency	Percent
Valid	Canada	95	50
	Belgium	4	2
	France	55	29
	Germany	13	7
	Netherlands	16	8
	UK	8	4
	Total	191	100

Table 4 shows the distribution of these participants based on their provinces in Canada.

Table 4. Canadian participants' provinces

		Frequency	Percent
Valid	AB	7	7
	BC	13	14
	ON	26	27
	QC	46	48
	Other	3	3
	Total	95	100

In each sample for Canadian firms, there are 48 SMEs and 42 LEs. Table 5.

Table 5. Canadian participants firm's size

		Freq.	Percent	Valid Percent
Valid	SME	48	52.2	52.7
	LE	43	46.7	47.3
	Total	91	98.9	100.0
Missing System		1	1.1	
Total		92	100.0	

In each sample for European firms, there are 48 SMEs and 42 LEs. Table 6.

Table 6. European participants firm's size

		Frequency	Percent
Valid	SME	48	50.0
	LE	48	50.0

	Total	96	100.0

4. RESULTS

The results of the descriptive statistical analysis in this research are categorized in four parts: identifying most frequent open innovation practices in Canada, frequency of applying top practices in Canadian English and French provinces and comparing Canada with Europe.

4.1. Frequency of applying open innovation practices

The frequency of applying open innovation practices in Quebec versus rest of Canada is presented in figure 6. Based on the descriptive analysis Canadian and Quebecers are almost applying open innovation practices with the same frequency except practices 7, Assigning a research fund to an academic institute, which is applied with a higher frequency in Quebec.
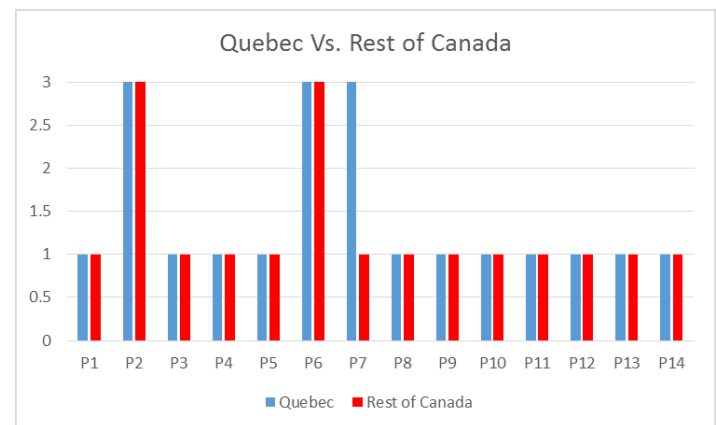

Figure 6. Open Innovation Practices Frequency, Quebec Vs. rest of Canada – Mode

4.2. Frequency of Applying Top Practices in Canada

In this part, by applying descriptive statistical analysis, cross tabulation, the frequency of applying top open innovation practices, which are identified in part 4.1, in English and French provinces of Canada are compared.

Within firms in both French and English provinces, Collaborating with students in a research agreement with a university, is applied with a high frequency. Although French firms are using this practice more than English ones. Figure 7.
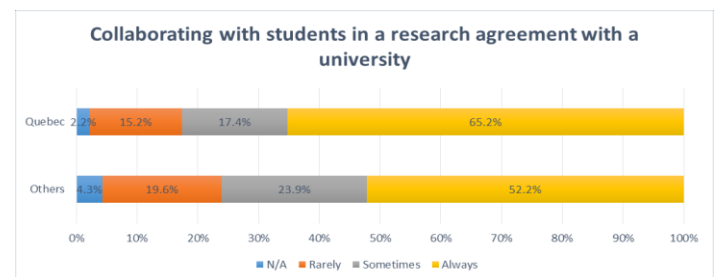

Figure 7. Practice 6 frequency in Canadian provinces

Within firms in both French and English provinces, Contract with other companies for R&D services, is applied with a higher frequency in French provinces. Figure 8.
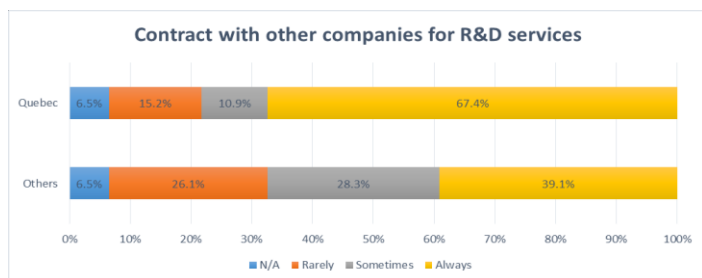

Figure 8. Practice 2 frequency in Canadian provinces

Within firms in French province of Quebec, Assigning a research fund to an academic institute, is applied with a high frequency. However, in English provinces of Canada this practice is applied rarely. Figure 9.
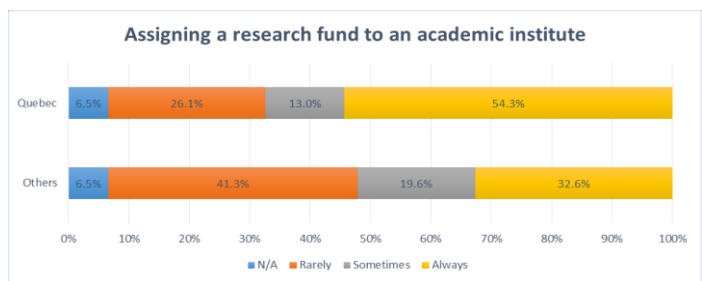

Figure 9. Practice 7 frequency in Canadian provinces

4.3. Canada Vs Europe

Figure 10 shows the mode of the open innovation practices within Canada and Europe. Majority of the participants are applying practice 2, 6 and 7 more frequently than the others in both regions.
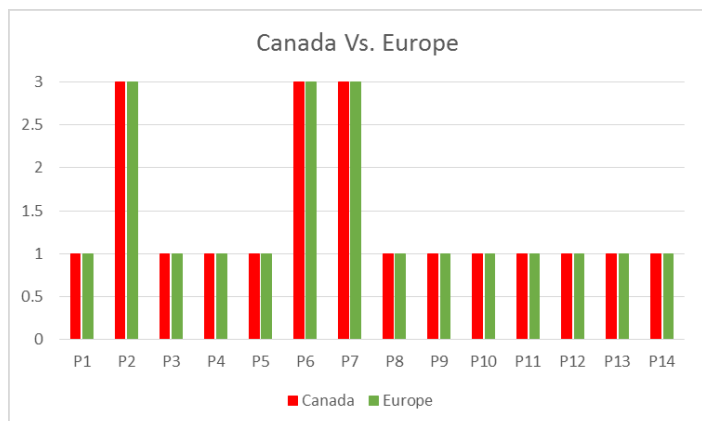

Figure 10. Open Innovation Practices Frequency, Canada Vs Europe – Mode

4.4. Frequency of applying top practices in Canada Vs Europe

The frequency of applying "Contract with other companies for R&D services" is almost similar in both regions. Figure 11.
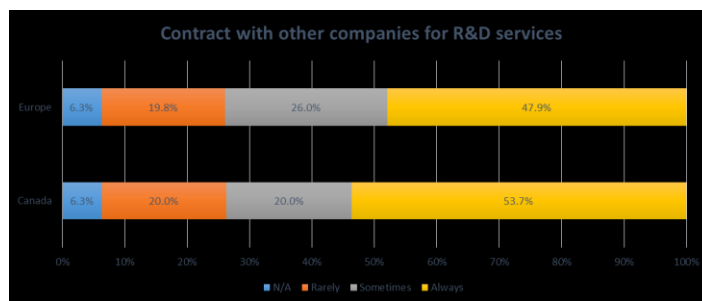

Figure 11. Practice 2 frequency in Canada Vs Europe

The frequency of applying "Collaborating with students in a research agreement with a university" is higher in European firms than Canadians. Figure 12.
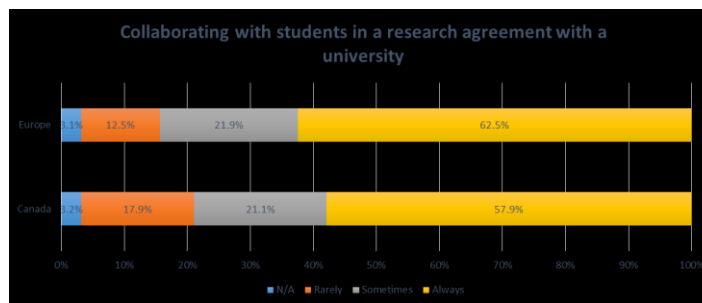

Figure 12. Practice 6 frequency in Canada Vs Europe

The frequency of applying "Assigning a research fund to an academic institute" is higher in European firms than Canadians. Since 33.7% of Canadian firms applying this practice with a low frequency. Figure 13.
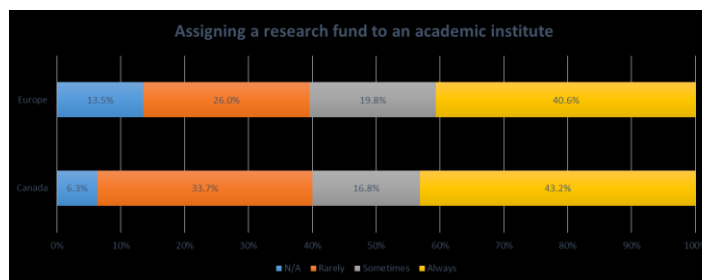

Figure 13. Practice 7 frequency in Canada Vs Europe

5. CONCLUSION

Top practices which are applied in Canada are almost the same practices which are practiced in pioneered countries of this type of business model in Europe. However, the frequency of applying open innovation practices related to university collaboration in Europe is higher than Canada.

Collaborating with students in a research agreement with a university, assigning a research fund to an academic institute and

Contract with other companies for R&D services are the most frequent practices of open innovation in Canada.

In comparing Quebec with other Canadian provinces, the difference is in frequency of university collaboration practices that Quebec has a higher frequency than rest of Canada. Since Quebec universities are living in a small community of French researchers; more collaboration in tightly groups can increase the chance of having more funding. (Ebadi & Schiffauerova, 2015)

The top three open innovation practices which are identified are all outside-in pecuniary practices.

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