The Propensity to Export and R&D: Does size matter?

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Abstract

This paper investigates the connection between the propensity of firms to export and their proclivity to conduct research and development activities (R&D) at the sector level. Specifically, we attempt to show empirically what has been a central tenant of international business theory for decades: R&D can represent an important internationally exportable competitive advantage for firms. The analysis uses a database that was constructed from a survey of 34,509 enterprises in Canada with annual gross revenues of less than $50 million (CDN) that was conducted between September 2004 and March 2005. The survey had a response rate of 47% and covered all significant sectors of the Canadian economy with the exceptions of government/quasi-government organizations (schools, hospitals etc.) and not-for-profit organizations.

Introduction

Firms can have different motivations, and/or strategies for (1) their research and development activities (R&D) and (2) their international exporting activities. This paper empirically investigates at the sector level the characteristics of firms who choose to perform R&D and to operate internationally. The purpose of the paper is to better understand why some firms choose to engage in these potentially risky activities, albeit activities that present an opportunity for greater financial performance while other firms choose not to engage in these activities. Succinctly stated this represents the essential purpose of the study of international business and of innovation which have been undertaken for several decades now.

R&D and exporting are quite different types of activities for firms, yet the goal of each is quite similar: to grow the firm, even in the face of increased risk. Risk can come in a number of different forms; business, technological, political, economic etc. [1] The industry, country (including its political climate and public policies), and financial infrastructure that the firm faces, we hypothesize, are also likely to impact on the decisions of managers to undertake the increased risks associated with either exporting or conducting R&D. In this paper we test the importance of a number of financial variables on the decisions

[1] Business risk, as used here, refers to the risk associated with offering a product/service in free markets where customers can exercise choice. Technological risk refers the possibility that R&D projects will fail to develop the types of products that they are intended to produce. Political risks relate to the possibility that political changes within a country will have a significant effect on the operations of the firm. Changes in the general economy such as a shift in interest rates constitute economic risks.

of firms to conduct R&D and to export using a large and representative survey of over 34,000 Canadian firms conducted during the autumn of 2004 and the spring of 2005.

Literature Review

Context – R&D, Exporting and Strategy

At the most basic level, firms can use their R&D activities to seek one of two objectives: (1) to create a competitive advantage[2] by developing innovations[3]; or (2) to defend against the actions of other firms or broader changes in society also by developing innovations[4]. Traditionally, this first objective has involved attempts to create products that are: smaller/lighter, faster/more powerful, more energy efficient/more capable, easier/less expensive to produce, more durable or in some other ways better than existing or previous products. Important examples from the last 15 to 20 years, however, have forced managers (and management researchers) to look at technology in a broader perspective.[5]

Exporting can also be viewed in a similar light. Firms either attempt to (1) capitalize on a competitive advantage by selling products/providing services to consumers from other countries or (2) they enter new markets in order to defend their positions in their home markets, perhaps in response to the movement into their home markets by a foreign competitor. Variations on these two themes exist and this highly simplistic dichotomy is only intended to define strategic actions for the highest level of analysis.

Small and medium-sized firms (SMEs) represent the vast majority of firms in industrialized countries such as Canada and make very important and essential contributions to the economy, particularly as employers of large number of workers but also as exporters. While some industry leading firms could, by some definitions, be considered small or medium-sized (when defined only by the number of people they employ), most SMEs, individually, play an important but narrow role in global markets. Some of these firms competitive advantage may extend from their physical location, their networks of social contacts/relationships or some other characteristic. Indeed, for some firms R&D may only be a secondary (or even lesser) consideration. Many firms conduct little if any R&D and only when they are absolutely required to do so. These firms can nonetheless be successful, in that they continue to exist, and may even prosper and grow under these circumstances.

In the past, R&D and exporting strategies were primarily the domain of large firms. Considerable resources are required to undertake either of these activities. In the case of R&D, it has been argued that large firms are able to better spread the investment across more products and/or outputs. (Cohen and Klepper, 1996) Exporting can also require considerable resources, including fixed assets which can act as

[2] As Michael E. Porter has said, "Competitive strategy is about being different. It means deliberately choosing a different set of activities to deliver a unique mix of value." This is the core of sustainable competitive advantage that Porter speaks of.

[3] Joseph Schumpeter defined 5 types of innovation; product, process, material, market and organization.

[4] It is important to note that innovations can be considered (1) new to the world, (2) new to the industry or (3) new to the firm. Even when firms undertake innovation for defensive purposes the goal is typically to develop an innovation, but perhaps an innovation that is not new to the world, or even new to the industry but is nonetheless new to the firm undertaking the R&D.

[5] Firms such as Dell have shown that even in industries where the focus of firms has tended to be on technological performance characteristics (smaller/lighter, faster/more powerful etc.) it is possible to use technology to improve customer services (i.e. improving the customer purchasing experience) and/or to focus on supplier management (improving the management of the value chain) to become the dominant players in a market. Wal-Mart provides a different, yet in many ways comparable example to Dell of how firms can use R&D as a tool to establish a competitive advantage in an industry. In Wal-Mart's case, technology has been used to develop a world-class logistical/transportation system which has, in-part, allowed the firm to decrease costs and prices for consumers.

a barrier to entry for many smaller firms. (Wakelin, 1998) This said, in the global economy of today, supply-chains have been fragmented under separate ownership structures, which has allowed for ever greater specialization and increased productivity at a global level. As a result, we have seen the development of many mini-multinationals. These mini-multinationals are small and medium sized firms (SMEs) who supply global markets often with very specific types of components or products. Many of these mini-multinationals maintain R&D functions which can be a key source of competitive advantage.

Exporting can be seen as an example of how firms can use competitive advantage to expand and achieve greater economic returns. In some situations, exporting may be required for economic viability. Certain markets are either so specialized or so limited that they require even small firms to capture a large geographic market just to exist. Consider for example the pharmacological treatment of rare and unique diseases which may affect only a small number of individuals but across a vast geographic space. With the liberalization of trade policies internationally, exporting need not only be the domain of very large firms operating on the basis of economies of scale.

The literatures regarding R&D and exporting are deep and rich owing both to the potency for these types of activities at producing exceptional returns for individual firms and to the inherent risks involved in such activities. Previous research in the areas has produced a number of important observations and conclusions related to the issues involved in this paper.

Research on R&D and Firm Size

The relationship between R&D and firm size has received a great deal of attention since the time of Joseph Schumpeter. The so-called 'Schumpeterian hypothesis' suggests that large firms in concentrated markets will conduct the bulk of R&D activity and hence dominate when it comes to innovation. Most of the work on R&D and firm-size had focused on proving or disproving this hypothesis.

There are a number of conceptual and methodological issues relating to the research that has been conducted on the R&D activities of firms. Conceptually, R&D is conducted within firms for specific purposes; to develop new industrial products/ services or to improve the way that products/services are made/delivered. R&D is a means to solving important problems faced by the firm. Most studies of R&D and firms size focus on the amounts that firms spend on R&D, or the input into the innovation process. Some studies have however focused on the performance or effectiveness of R&D, meaning that they wish to use measures of R&D output, such as innovations (Pavitt, Robson and Townsend, 1987) or patents filed by firms. (Scherer, 1965) Both approaches can be useful but both also have limitations/weaknesses.

The key challenge facing studies that focus on R&D spending (or the input measure) is the possibility that R&D will not be performed either efficiently or effectively. Resources could be directed towards the wrong ends or the resources could simply be mismanaged. The key benefit of using R&D spending is the access to information or data that exists for this measure. Figures for R&D spending are often readily accessible from publicly-traded companies' annual reports.

Those studies that attempt to determine R&D effectiveness must contend with the inherent problems associated with the complexity of business activities and the ability to attribute business success to specific R&D efforts or R&D outputs. The study of patents is one method by which researchers have attempted to determine effectiveness of R&D spending, with the critical assumption being that patents represent success of R&D activities/projects. The problem is that some patents will be very valuable while others may be virtually worthless. It can be very difficult, and possibly not even worthwhile from a researcher's perspective, to try to unravel the complex network through which each individual patent adds value to a firm. The literature on innovation systems articulates well the challenge of complexity and the

identification of value-added. (Lundvall, 1992; Nelson, 1993) As a means of addressing these challenges some researchers have looked at the number of patents produced per dollar of R&D expenditure.

At the most basic level, research has shown that R&D spending and firm size[6] are positive correlated. (US National Science Foundation, 1961; Link, 1981; Pavitt, Robson and Townsend, 1987) This makes intuitive sense since larger firms will tend to have more resources available to undertake what can be very expensive R&D activities. When we shift our focus to R&D outputs, such as innovations, the picture is less clear. Specifically, it has been shown that while large firms tend to undertake more R&D and as a result tend to innovate frequently, (Pavitt, Robson and Townsend, 1987) smaller firms are often the generators of the less frequent, but extremely important, radical innovations. (Christensen, 1997) Radical innovations change markets and drive the creative destruction process that Schumpeter described. (Tushman and Anderson, 1986; Christensen, 1997) These findings do differ across industrial sectors and do not always indicate a linear trend towards increasing innovation as size (by employment) is increased. (Pavitt, Robson and Townsend, 1987) A number of studies, including Soete (1979) have discovered an 's' shaped relationship between size of the firm and R&D activities.

The primary data used in this paper does not allow for these types of relative analysis and therefore we will avoid a detailed account of this intriguing area of research.

In a paper by Dasgupta and Stiglitz (1980), the authors make an important and interesting assertion regarding the nature of the relationship between firm size and R&D. They argue that:

> "except in the short run *both* market structure and the nature of inventive activity are endogenous; that the degree of concentration in an industry ought not to be treated as given…that they both depend on more basic ingredients, such as the technology of research, demand conditions, the nature of the capital market (i.e. market rates of interest, and the ability of firms to borrow to finance research and development, and the legal structure (e.g. patent rights). But as they are both endogenous, their relationship, unlike the neo-Schumpeterian thesis, ought not to be regarded as a causal one." (Dasgupta and Stiglitz, 1980, emphasis in the original).

R&D is not a function of market structure, nor is market structure necessarily a function of R&D activities but both are affected by a panoply of issues. This does not dull our interest in the relationship between firm size and R&D activities, for the relationship between R&D and firm size in the short-term for individual industries may be of significance for both managers and public policymakers, the persuasive argument of Dasgupta and Stiglitz leads us to look for relationships amongst other endogenous variables such as access to financing or capital markets.

Innovation and Exporting

As was previously stated, there is a logical and conceptual connection between innovation and the exporting activities of firms. The argument is that firms that are innovative, particularly those who develop world-first products will be able to expand their business and increase financial returns by selling their products to worldwide markets.

Focusing for a moment on the relationship between firm size and exporting we note that a number of studies (Kumar and Siddharthan, 1994; Wagner, 1995; Willmore, 1992; Wakelin; 1998; Bernard and

[6] The earlier research of the 1960's and 1970's tended to utilize the number of R&D employees within a firm rather than total expenditures on R&D which could led to some distortions of findings. See Soete (1979) for a discussion of relating issues. The finding that size and R&D tend to be positively correlated at least generally speaking, holds in most situations, regardless of the measure of R&D or the measure of firm size used.

Jensen, 1999; and Sterlacchini, 1999) have observed an inverted U shaped relationship between firm size and exporting, at least at the plant level.

In a study of 640 Indian firms, Kumar and Siddharthan (1994) found that R&D expenditures were an important determinant of exporting for low and medium technology industries. A study of another industrializing nation, Brazil, found no relationship between R&D expenditures and exporting. (Willmore, 1992) An older study of Israeli firms found a significant relationship between R&D expenditures and exporting activities when a lag for the R&D expenditures was introduced. (Hirsch and Bijaoui, 1985) Studies in the industrialized world, such as the UK, have found very specialized relationships between innovations (which is not the same as R&D but is in-part driven by R&D) and exporting. Wakelin (1998), using the SPRU database of innovations, found that large firms that introduced innovations were more likely to export and those that innovated more often were even more likely to engage in exporting than non-innovating firms. The situation for small firms was quite different, whereas, small non-innovative firms were actually more likely to export than small innovating firms (at least those small firms that introduced only one or a small number of innovations). Braunerhjelm (1996) studied the role of investments in R&D and skilled labour labour development on the likelihood of firms to export in Sweden. In this work, a positive relationship was observed between R&D, investments in skilled labour development and exporting while no relationship was found to exist between traditional cost factors and exporting.

Roper and Love (2002) also studied the relationship between innovation and exporting. In their work, Roper and Love investigate the innovation and export performance of firms at the level of individual manufacturing plants. They looked at both the probability of firms to export and the proclivity to conduct R&D. A first useful finding from their work is the strong positive correlation between innovation and export activities within their sample of both UK and German firms. The data that they used was not constrained to SME's (as the data we use is) and is determined to be "representative of the industry, regional and sizeband distribution of manufacturing in each country." (Roper and Love, 2002) This finding is broadly consistent with that of Wakelin (1988). It is also consistent with the fidings of Doutriaux (1993) who showed that R&D and product orientation were major determinants of small high-tech firms export propensities, and of Roper (2002) who observed that having a unique product (or service) and a technological advantage over competitors was a basic characteristics of exporting SMEs.

Sterlacchini (1999) took the novel approach of studying non-traditional indicators of innovation, including: design activities, investment in capital goods, engineering and pre-production development activities. The study looked at the role of these types of activities in determining the export activities of firms in non-R&D intensive industries in Italy. Firms for the study were from the supplier-dominated manufacturing industries of clothing, knitwear, wood and furniture, footwear, plastic products and dies. The research found that the non-traditional innovation indicators did affect the propensity of firms to export.[7]

Conceptual Model and Hypotheses

Given the forgoing discussion relating to R&D and exporting we have developed a number of hypotheses that we wish to test using the Statistics Canada Survey of Financing of Small and Medium Enterprises (2004-2005). Our objectives are therefore to: (1) test for the effect of firm size on the relationship between exporting and R&D activities, (3) to test for any relationships between the characteristics of the majority owner (i.e. age and experience) and then to (3) explore the relationship(s), if any, between R&D activities, exporting and access to various forms of financing.

[7] The work concluded that exporting was mostly determined by the size of the firm and whether or not the firm was an outsourced contractor.

These hypotheses relate to a conceptual model that is premised on risk and the ability of firm's to undertake risk. Specifically, as has been argued, both R&D and exporting represent risky undertaking by firms that require considerable financial resources. Large firms, will typically have a greater ability to finance the investment into both (or either) R&D and exporting. Since a number of studies previously mentioned have shown a relationship, at minimum, between firm size and the absolute size of R&D activities, we hypothesize that:

> *H1: There will be a positive relationship between R&D and firm size for all industries studied, except those with a primarily local line of business and/or those in which there exist an oligopolistic market structure. As our study covers only small firms, we would therefore expect that the relationship will not hold for Accommodation/Food Services, Transportation/ Warehousing and Finance/Insurance/Real Estate.*

Accommodation Services in Canada have become increasingly dominated by a relatively small number of corporations who offer a price/service segmented line of products. Corporations such as the Intercontinental Hotel group offer a variety of styles of accommodation from luxurious (Intercontinental) to basic (Holiday Inn Express) to suites (Candlewood Suites).

Food Services have also started to see chains develop, particularly in the lower-priced sections of the market. Fast food chains such as McDonald's, Wendy's and Subway have been important players in this industry for some time but we also see the expansion of some national chains in Canada such as Boston Pizza and Montana's Cookhouse as well as some multinational chains including Denny's and Outback Steakhouse and Prime Restaurant Group (East Side Mario's, Casey's). None of these food services firms qualify for inclusion in the Statistics Canada survey of financing of SMEs.

The large capital costs involved in the Transportation industry as well as the economies of networks involved dictate a largely oligopolistic market structure. Finance/Insurance/Real Estate are also dominated by large firms in-part because of the network economies involved but also because of the heavy regulations involved in financial markets and the ability to manage financial risks within large diversified operations. As such, most of the large and dominant players in these industries are excluded from this survey.

> *H2: There will be a positive relationship between R&D expenditure and exporting.*

R&D is often used to develop a competitive advantage for firms. If the firm's R&D activities are successful at developing a competitive advantage, some of the risks associated with exporting will be mitigated against. We expect to observe this relationship for all sizes of firms and for each industry where there are at least a minimum number of observations available. This relationship has also been found to exist in some of the previous studies of R&D and exporting. (Roper and Love, 2002; Kumar and Siddharthan, 1994; Hirsch and Bijaoui, 1985).

> *H3: Access to finance (publicly traded firms, government grants and credit from suppliers) will affect the decisions of firms to export and to conduct R&D.*

R&D and exporting are risky endeavours, and therefore, access to sources of financing may be important for firms who are considering these activities. It may be interesting to investigate whether or not firms regard certain types of financing as different than others (i.e. are firms more willing to undertake risky activities such as R&D or exporting when they receive equity versus debt financing).

Methodological Approach

Our investigation of the impact of firm size on the relationship between the export intensity of SMEs and their R&D intensity[8] will be tested for each sector of the economy. The R&D intensity of a firm, of course, is only one of many factors that may affect its export intensity. A multivariate model including as many of those factors as feasible is therefore needed to explain a firm's export behavior. This work starts with a simple bivariate model to test for the existence of a relationship between export and R&D intensities in each sector of the economy. A multivariate model incorporating a number of other factors is then used to test which of those factors, in addition to R&D intensity, help to discriminate between exporters and non exporters.

A correlation analysis of the relationship between export intensity and R&D intensity would be inappropriate because there is no reason to assume that those two variables are linearly related. The study therefore starts with a series of crosstab analyses which do not make assumptions on the shape of the relation between two or more than two variables. It is followed by a logistic regression analysis to identify the factors which best make a difference between exporters and non-exporters.

Source of Data

This empirical analysis on which this project is based uses data collected by Statistics Canada between September 2004 and March 2005 under its Survey on Financing of Small and Medium Enterprises, 2004. This survey is part of Statistics Canada's SME Financing Data Initiative designed to inform public policy decisions related to SME financing. In addition to a number of specific questions about forms of, and access to, financing there are questions regarding both the R&D and exporting activities of firms.

Firms included in the survey had, in 2004, less than 500 full-time employees and annual gross revenues below $50 million. Financing and leasing companies, co-operatives, subsidiaries, non-profit organizations, government offices, schools, hospitals and other public sector organizations are not included in the survey.[9] The sample size for this survey was 34,509 firms from the Statistics Canada Business Register. Valid responses were received from 13,042 SMEs, a response rate of 47% of eligible potential respondents.

The sample was stratified to better represent all sectors of economic activities and firm sizes in the target population. Statistical inferences and tests are based on data in the sample. Whenever feasible, sampling weights are used to get population estimates.

Profile of SMEs: Export Intensity, R&D and Size

Preliminary findings from the Statistics Canada Survey on Financing of Small and Medium Businesses show that in 2004, eight percent of Canada's SMEs exported and that the larger SMEs have a higher propensity to export than the small ones (25% of firms with 20 to 99 employees exported, compared with 6% of the firms with 1 to 4 employees and 8% of the firms with no employees). On the average, exporting SMEs exported 33% of their sales, very small exporters (0 employees) exporting a higher proportion of their sales (38%) and larger exporters (20 to 99 employees) exporting a lower proportion (29%). Sectorally, manufacturing firms have the highest export orientation (31% of

[8] In this paper, export intensity and R&D intensity are defined as the ratio of exports to total sales and of R&D to total sales, respectively; export propensity and R&D propensity are defined as binary variables indicating if a firm is exporting or not exporting, or doing some R&D or not doing any R&D.
[9] More information on this survey can be found at www.statcan.ca, ref. # 2941.

manufacturing firms are exporting an average of 30% of their sales), and accommodation and food services, and other services have one of the lowest export orientation among Canadian sectors of economic activity (4% and 3% respectively of firms export an average 37% and 25% of their sales). These observations show clearly that size and sector of activity are two important determinants of a firm's export orientation.

R&D intensity is another characteristic of SMEs which shows wide differences between sectors. Average R&D intensities in professional services, manufacturing and other services are respectively 5.41%, 4.83% and 3.88% whereas it is only 1.87% in construction, 2.14% in transportation and warehousing, and 2.19% in accommodation and food services (Table 1). Differences between those mean R&D intensities are due in part to the percentage of firms which do not do any R&D, up to 80% for accommodation and food services, down to 59% for manufacturing and 63% for professional services. For all sectors combined, data in the sample show that there are significant statistical relations between R&D intensity and the development stage of the firm (p-value = 0.000) and between R&D intensity and the age of the majority owner (p-value = 0.02): a smaller percentage of start-ups than of established firms have R&D activities, but when they do, start-ups do more R&D than the established firms; and majority owners in the 30 to 49 age groups do more R&D than younger and older majority owners.

There are big size differences between sectors, accommodation and food services and manufacturing having the highest average number of full-time equivalent employees (17.60 and 13.89 respectively) and finance, insurance, real estate, and professional services having the smallest average number of employees (means of 3.84 and 6.56 respectively, Table 2). Differences are due in part to the proportion of firms with no employees, close to 70% of the firms in finance and in professional services have no employees, compared with only 18% and 36% in accommodation and food services and in manufacturing. Globally, the average SME in the sample has 9.26 employees: 50.7% of SMEs in the population surveyed have no employees, 32.6% have 1 to 5 employees, 11.7 have 6 to 15 employees, 4% have 16 to 50 employees and only 1.1% have over 50 employees[10].

Empirical Analysis

R&D intensity and firm size are the two key characteristics of exporting SMEs considered in this study. A series of crosstab analyses was performed to analyze their relationship. Three levels of R&D intensity were considered (no R&D, 1% to 10% of sales, over 10% of sales), and three levels of number of full-time equivalent employees (no employees, 1 to 5 employees, and 6 and more employees)[11]. As shown by the data reported in Table 3, a statistically significant positive relationship between R&D intensity and firm size is observed in construction, in manufacturing, in professional services, other services, and in transportation and warehousing. No relationship between R&D and size is observed in the primary sector, in wholesale and retail, and in accommodation and food services, three of the sectors with the lowest percentage of firms active in R&D. That there was not significant relationship observed for these three sectors (primary, wholesale/retail and accommodation/food services) is not necessarily surprising, given that various studies (Soete, 1979) have noted an S shaped relationship between R&D activities and firm size. Recalling as well that the sample used for this research truncates larger firms from each sector, it is possible that a positive relationship does still exist for these industries but the sample is not able to adequately capture this relationship.

[10] The largest firm in the sample has 510 employees (full-time equivalent). The survey targeted firms with up to 500 full-time employees. The full-time equivalent is equal to the number of full-times plus 0.2 times the number of part-times.

[11] Firms with 6 and more employees had to be aggregated into a single group to get the minimum 5 expected observations in each cell of the crosstab analysis.

Exporting and R&D are strongly related. A comparison of the exporting propensity of a firm (exporters and non exporters) and of its R&D propensity (not doing any R&D and doing some R&D) show significant relationships in most sectors (Table 4). Exceptions include transportation and warehousing where the relationship is not significant, and finance, insurance real estate and accommodation and food services where there are not enough firms doing R&D to get the minimum number of expected observations needed for the chi-square test to be acceptable.

A crosstab analysis of the rapport between the export propensity of a firm and its R&D propensity by firm size shows a significant relationship between these two factors in the larger SMEs (6 and more full-time equivalent employees) in most sectors of operation (Table 5). The relationship is not significant, however, for smaller firms in the primary sector and in manufacturing. And it is not possible to conclude because of the small size of the samples in the construction sector, in finance, real estate and insurance, in accommodation and food services, and in transportation and warehousing.

The analysis reported in Tables 3, 4 and 5 has shown clearly that size and R&D propensity are three factors closely related to export propensity in most sectors of operations. Other variables can also affect firm behaviour and its ability to export, in particular the experience of the majority owner (EXP10, having a majority owner with over ten years of experience) and access to financing (government grants, equity financing, suppliers' financing, subsidies, other external financing). A logistic model was used to evaluate the contribution of those additional variables in discriminating between exporters and non-exporters. As reported in Table 6, the sector of operation of a firm (especially manufacturing and professional services), its R&D intensity, the experience of its majority owner, having looked for equity financing or requested external grants and subsidies, and firm size contribute significantly to explaining if a firm is an exporter or a non-exporter. Other forms of external financing are also important. However, because of multicollinearity, this logistic regression analysis does not allow us to tell if one source of external financing is significantly better than another.

Even if most of the factors included in the logistic regression of table 6 are significant, they contribute only marginally to our understanding of what is an exporting or a non-exporting firm: only 12.4% of actual exporters are classified as exporters by the model (Table 7). More analysis will be needed to increase our understanding of the linkage between R&D and exporting.

Conclusions and Discussion

In this preliminary work we have begun to investigate the relationship between R&D activities and exporting in Canadian industry. The sample data that we have to work from provides a number of interesting opportunities, which we have only just begun to utilize. In particular the size of the sample and the information regarding financing of activities present opportunities to explore how firms develop and finance competitive advantage in ways that have not been attempted before.

For all the potential there are a number of limitations as it pertains more narrowly to the study of R&D and exporting. First, research possibilities are constrained by the focus on SMEs. While unquestionably an important segment of firms to study, this excludes a significant portion of the R&D conducting and exporting firms in Canada. Additionally, the survey only provides an indicator of innovation inputs. The issues of effectiveness and efficiency of R&D activities that were discussed earlier can not be addressed by this survey, at least not in isolation. Furthermore, many of the approaches that have been used in previous research cannot be replicated using this data which excludes the possibility of direct comparison.

This initial work has produced a number of useful finding for future work. First, we have observed a rather strong relationship between R&D activities and exporting which does appear to confirm

some of the findings of previous research. Indeed, referring to Table 4 we see that only the Transportation and Warehousing sector had a sufficient number of observations for each of the cells in the analysis and did not produce a significant relationship between R&D activities and exporting. When the sample is stratified for firm size (as given by full-time equivalents) there are also mostly significant relationships between R&D and exporting, however the lack of significance for the lower classes of manufacturing and primary sector firms is somewhat befuddling.

Finally, there are clearly some issues with regards to the logistic regression presented in Table 6 that should be addressed. Specifically the issue of multicollinearity must be further explored and may indicate a limitation of the data itself. Our next steps will include a Probit analysis of R&D and exporting activities and more focus on differences between sectors of economic activity. In the logistic regression analysis used for this work, we treated exporting as a binary variable, where firms were either classified as exporters (those firms who did at least some exporting) or non-exporters (firms who did no exporting whatsoever), and we lumped all sectors together. However the data will allow the exporting variable to be treated as continuous but finite function of total sales, and sample size will allow individual analyses at the sector level.

Table 1
Distribution of firms by R&D intensity, by sector

Sector	Sample		Population estimates				
	Number of firms	Mean R&D intensity	Total number of firms	R&D intensity			
				No R&D	1-10%	11-20%	Over 20%
Total	**8427**	**3.32**	**1357347**	**71%**	**20%**	**5%**	**4%**
Primary	1264	2.34	163902	76%	20%	3%	2%
Construction	814	1.87	173635	76%	21%	1%	2%
Manufacturing	993	4.83	64041	59%	26%	10%	5%
Wholesale & Retail	1376	2.41	192370	72%	19%	6%	3%
Finance, Insurance, Real Estate	244	2.06	82348	70%	25%	4%	1%
Professional Services	1535	5.41	233231	63%	21%	7%	9%
Accommodation & Food Services	636	2.19	71196	80%	15%	4%	1%
Other Services	1077	3.88	304274	72%	17%	7%	5%
Transportation & Warehousing	488	2.14	72350	77%	17%	4%	3%
Percentages may not sum up to 100 because of rounding							

Table 2
Distribution of firms by size (FTE equivalent) by sector (Number and percentage of firms)
Firms with no missing values on Export and R&D

Sector	Sample		Population estimates			
				Number of employees (FTE)		
	Number of firms	Mean number of employees	Total number of firms	None	1 to 5	Over 5
Total	**8125**	**9.26**	**134271**	**51%**	**33%**	**15%**

			9			
Primary	1227	8.26	163365	62%	29%	8%
Construction	797	6.58	172717	49%	37%	14%
Manufacturing	928	13.89	61252	36%	34%	30%
Wholesale & Retail	1330	9.91	190679	42%	35%	23%
Finance, Insurance, Real Estate	241	3.84	81435	68%	19%	13%
Professional Services	1501	6.56	231628	68%	25%	7%
Accommodation & Food Services	586	17.60	67244	18%	41%	41%
Other Services	1045	7.99	302675	43%	42%	16%
Transportation & Warehousing	470	8.18	71724	62%	29%	9%
Percentages may not sum up to 100 because of rounding						

Table 3
Relationship between R&D intensity (3 levels) and Size (Full Time Equivalent, 3 levels)
Chi-square analysis

Sector	**Sample statistics**			**Weighted population statistics**
	N	Chi-Square	Sign.	N
Primary	1227	5.87	.218	163364
Construction	**797**	**17.30**	**.002**	172717
Manufacturing	**928**	**19.66**	**.000**	61252
Wholesale & Retail	1330	7.85	.097	190680
Finance, Insurance, Real Estate	**241**	n.a. *	n.a. *	81434
Professional Services	**1501**	**42.05**	**.000**	231628
Accommodation & Food Services	586	7.19	.126	67245
Other Services	**1045**	**11.21**	**.024**	302677
Transportation & Warehousing	**470**	**20.06**	**.000**	71726
* sample too small to conclude (some cells with less than 5 expected observations)				

Table 4
R&D and Exporting, chi-square tests

Sector		**Sample**			**Weighted Population**	
		No R&D	**Some R&D**	**2-sided significance**	**No R&D**	**Some R&D**
Primary	Non Exporting	819	302	**.000**	115611	33870
	Exporting	75	68		8218	6203
Construction	Non Exporting	641	160	**.000**	131415	40020
	Exporting	4	9		227	1974
Manufacturing	Non Exporting	370	248	**.000**	28431	15234
	Exporting	134	241		9139	11238
Wholesale & Retail	Non Exporting	878	277	**.000**	127228	40967
	Exporting	125	96		13658	13658
Finance, Insurance, Real Estate	Non Exporting	187	51	n.a.*	56004	24543
	Exporting	5	1		134	134
Professional Services	Non Exporting	746	458	**.000**	134254	70711
	Exporting	127	204		16187	16187

Accommodation & Food Services	Non Exporting	476	157	n.a.*	57087	14080
	Exporting	2	1		10	10
Other Services	Non Exporting	645	303	**.000**	215196	76847
	Exporting	47	82		9376	9376
Transportation & Warehousing	Non Exporting	333	86	.163	51549	13506
	Exporting	51	20		3261	3261
* sample too small to conclude (some cells with less than 5 expected observations)						

Table 5
R&D and Exporting, by Size (number of employees, FTE)
Chi-square analysis, 2-sided levels of significance

Sector	**Sample, FTE class Chi-square analysis**			**Sample size by number of employees (FTE)**				**Population estimates by number of employees (FTE)**			
	0	1 to 5	Over 5	Total # of firms	Number of employees			Total # of firms	Number of employees		
					0	1 to 5	Over 5		0	1 to 5	Over 5
All sectors (N=8427)	**.000**	**.000**	**.000**	8125	2616	3100	2409	1342719	688490	446794	207435
Primary	.059	.166	**.000**	1227	436	503	288	163365	101818	48051	13496
Construction	n.a.*	n.a.*	n.a.*	797	228	362	207	172717	85373	63917	23427
Manufacturing	.056	.133	**.000**	928	214	343	371	61252	22327	20619	18306
Wholesale & Retail	**.004**	**.001**	**.000**	1330	328	523	479	190679	79942	66863	43874
Finance, Insurance, Real Estate	n.a.*	n.a.*	n.a.*	241	137	66	38	81435	55003	15645	10787
Professional Services	**.000**	**.025**	**.000**	1501	721	444	336	231628	158224	57586	15818
Accommodation & Food Services	n.a.*	n.a.*	n.a.*	586	52	221	313	67244	12180	27709	27355
Other Services	**.001**	**.000**	**.000**	1045	334	438	273	302675	128863	125777	48035
Transportation & Warehousing	n.a.*	n.a.*	n.a.*	470	166	200	104	71724	44760	20627	6337
* sample too small to conclude (some cells with less than 5 expected observations)											

Table 6
Non Exporters vs. Exporters, Logistic Regression Analysis
All sectors

Variables in the equation	**B**	**S.E.**	**df**	**Sig.**	**Exp(B)**
R&D expenditures (C8025)	0.457	0.035	1	0.000	1.58
Number of employees (FTE)	0.011	0.001	1	0.000	1.01
Majority owner >10 years experience (EXP10)	0.210	0.074	1	0.005	1.23
Gov Grants (C3014) **	0.188	0.125	1	0.133	1.21

Equity Financing (C3004) **	0.298	0.166	1	0.072	1.35
External financing requested (C3000)	0.041	0.076	1	0.588	1.04
Credit from suppliers requested (C3002)	0.037	0.115	1	0.747	1.04
Grant, subsidy requested (C1103)	0.228	0.088	1	0.009	1.26
Sectors *			8	0.000	
Primary	-0.408	0.162	1	0.012	0.67
Construction	-2.342	0.310	1	0.000	0.10
Manufacturing	1.042	0.149	1	0.000	2.84
Wholesale & Retail	0.087	0.152	1	0.567	1.09
Finance, Insurance, Real Estate	-1.840	0.436	1	0.000	0.16
Professional Services	0.325	0.149	1	0.029	1.38
Accommodation & Food Services	-3.938	0.624	1	0.000	0.02
Other Services	-0.337	0.165	1	0.041	0.71
Constant	-2.767	0.155	1	0.000	0.06
Sample size	8427				
% correctly classified	85.5%				
Cox & Snell R Square	.125				
Nagelkerke R Square	.217				
Number of firms in sample, by sector	**Number of firms in sample**				
Primary	1265				
Construction	814				
Manufacturing	993				
Wholesale & Retail	1381				
Finance, Insurance, Real Estate	239				
Professional Services	1265				
Accommodation & Food Services	636				
Other Services	1077				
Transportation & Warehousing	497				
Total	8427				

* Reference sector: Transportation & Warehousing

** coefficients were significantly different from zero (p-value<0.05) before the introduction of variables C3000, C3002 and C1103 in the model, indicating some multicollinearity.

Table 7
Logistic regression analysis: observed vs. predicted exporters

Observed	**Predicted**		**Percentage correct**
	Non Exporter	Exporter	
Non Exporter	7046	89	98.8%
Exporter	1132	160	12.4%
Overall			85.5%

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