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How Innovative Are Canadian Firms Compared to Some European Firms? A Comparative Look at Innovation Surveys*

Pierre Mohnen†*, Pierre Therrien*‡

Résumé / Abstract

Cette étude examine à quel point l'enquête innovation canadienne de 1999 et les enquêtes communautaires européennes d'innovation CIS2 de 1997/1998 sont comparables. Quatre pays européens sont comparés au Canada: la France, l'Allemagne, l'Irlande et l'Espagne. Nous faisons ressortir des différences dans la réalisation de l'enquête et la formulation du questionnaire. Nous proposons des façons d'harmoniser les données pour les rendre aussi comparables que possible. Les performances entre pays diffèrent suivant l'indicateur retenu. Le Canada est loin en tête sur base du pourcentage d'innovateurs, mais se classe en dernière position sur base du chiffre d'affaires en produits innovants. Le Canada est à peu près à égalité avec l'Allemagne et l'Irlande pour ce qui est du pourcentage d'innovateurs dans le sens plus strict d'une première sur le marché. La France et l'Espagne sont moins performantes à cet égard, mais pas dans la proportion d'innovateurs au sens strict parmi les innnovateurs au sens large. A côté de ces differences se dressent aussi des régularités, telles qu'une plus grande propension à innover dans les enterprises des secteurs high-tech ou de grande taille. La part du chiffre d'affaires en produits innovants est également plus élevée pour les firmes des secteurs de haute technologie mais pas nécessairement pour les grandes firmes.

This paper investigates the comparability of the 1999 Canadian Survey of Innovation with the European Community Innovation Surveys for 1997/1998 (CIS2). Four European countries are compared to Canada: France, Germany, Ireland, and Spain. Differences in terms of design and implementation of the survey and formulation of the questionnaire are pointed out. Proposals are made to harmonize the two datatsets and make them comparable as much as possible. Different innovation indicators -- percentage of innovators, sale of innovative products – show different results across countries. Canada leads the pack by far if we consider the percentage of innovating firms in the respective country samples,

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however it ranks last if we consider the share in sales of innovative products. Canada, Germany and Ireland seem to be relatively similar regarding the percentage of first-innovators (a narrower definition of innovation). France and Spain lag behind in this regard but seem to have a high intensity of first-innovators among the innovators. Results also show some common trends for all countries studied. Firms in high-tech sectors are more frequently innovative and reach a greater share of revenue from innovation than firms in other sectors. Large firms are more often innovative but size is not always a good predictor for the percentage of revenue from innovation.

Mots Clés : Innovation, comparaisons internationals, indicateurs

Keywords: Innovation, indicators, international comparisons

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1. Introduction

Comparing cross-country innovative performances becomes more and more important as countries recognize the importance of innovation for economic growth. Most studies that compare innovative performances in industrialized countries use macroeconomic measures such as R&D expenditures, the number of scientific workers, patents and connectiveness. Even though these macro-economic variables are useful for interpreting and comparing national systems of innovation, more data at the micro-economic level are needed to deepen our understanding of the innovation process. Innovation surveys are carried out at the firm-level. They content valuable information about the enterprises and potential factors leading to innovation regarding the firm and its environment. To ensure international comparability of the surveys, the OECD has provided a general framework – the Oslo manual (OECD, 1996).

Using the Oslo manual as reference framework, the new Canadian survey of innovation (1999 Survey of Innovation) and the Second European Community Innovation Survey of 1997-98 (CIS 2) were both designed to allow international comparisons. However, even though the preoccupation with international comparability was at the core of both survey designs, some discordances remain. This paper investigates the comparability of the 1999 Canadian Survey of Innovation with the European Community Innovation Surveys for 1997/1998. Four European countries will be compared to Canada: France, Germany, Ireland, and Spain.

A first section compares and reconciles the surveys. Comparability is based on several criteria such as definition of innovation, sampling method and criteria, wording of questionnaire, and industrial classification. Section 3 summarizes the discrepancies between the two types of surveys and compares the innovative performance of each country using appropriately transformed data. In the conclusion we highlight the important findings after a first look at the data and suggest steps to analyse and compare (more in-depth) the innovative performance of the countries studied.

2. Comparison and reconciliation of surveys

2.1 Target population and sample

Statistical unit

Canada

The 1999 Survey of Innovation is based on a sample of "provincial enterprises" in the Canadian manufacturing industries[1]. A "provincial enterprise" consists of all establishments of a given enterprise in the same industry within a province. An enterprise can be represented more than once in the sample if the enterprise, for instance, owned two (or more) establishments producing the same product but in different provinces[2]. These observations, however, do not systematically

[1] The survey also includes selected natural resources industries but only manufacturing firms will be analyzed in this paper.

[2] In the same manner, if another enterprise owned two establishments producing different products in the same province, these two establishments are also considered as two different sample units.

duplicate the behavior of the enterprise as the same firm could face different competitive environments by province or industry and therefore react differently toward innovation.

However, it is expected that mostly large firms would be broken-down to become provincial-enterprises (small firm would usually be located in only one province producing only one product, as a result that provincial-enterprise and enterprise would be the same entity for these small firms). Therefore, the usual behavior of large firms (performing R&D, be more engaged in activities linked to innovation, etc.) would be over-represented in the Canadian sample, which could lead to an upward bias for Canadian firms.

EU

In CIS 2 the statistical unit is supposed to be the enterprise, defined as "the smallest combination of legal units that is an organisational unit producing goods or services, which benefits from a certain degree of autonomy in decision-making, especially for its allocation of current resources. An enterprise carries out one or more activities at one or more locations" (Eurostat, 1999a). If it is not possible to collect data at the enterprise level, the relevant statistical unit is a division of the enterprise group or a kind of activity unit.

To reconcile surveys

To compare surveys, it is appropriate first, to assess the bias resulting from the use of different statistical units (enterprise vs. provincial-enterprise). To do so, one would compare the whole Canadian sample with a sub-sample of Canadian single-location firms producing only one product. All enterprises that answered more than one questionnaire (meaning that it has been broken down into more than one provincial-enterprise) would be removed from the sub-sample. As mentioned before, this sub-sample of single-location firms would remove mostly large (innovative) firms, and could be considered as the lower bound regarding the Canadian firms' innovative performance. The real Canadian performance would correspond to results in between those obtained with the whole sample (higher bound) and those obtained from the sub-sample of single-location firms (lower bound)[3].

Industrial classifications

Canada

The 1999 Canadian survey of innovation used the 1997 North American Industry Classification System (NAICS-97). Using this new industrial classification should minimize biases (compared

[3] Comparison between the full sample and the sub-sample of single-location firms in the Canadian innovation survey of 1999 shows that the former has 80.3% of innovative firms whereas the latter has 79.4%. The two samples do not seem to differ drastically in that regard. Tests on other variables of interest were conducted and only minor and non-significant changes occurred. Therefore for the remaining of the paper, the whole Canadian sample will be used to compare the Canadian innovative performance to European countries.

to the previous SIC-80 industrial classification) when comparing to European countries, because NAICS-97 has been built to facilitate international comparisons. As stated in the introduction of the NAICS-97 Manual: "The statistical agencies of the three North American countries agreed that […] they would strive to create industries that, at least, did not cross the two digit boundaries of ISIC Rev.3" (Statistics Canada, 1997).

EU

The industry classification used in CIS 2 is the statistical classification of economic activities in the European Community (NACE Rev. 1). The industry corresponds to the class in which the principal activity of the unit is located, in terms of value added, or then gross output or number of persons.

To reconcile surveys

The publishing industry is, using the NACE taxonomy, a sub-group of the Printing industries (NACE-22). However, using the NAICS taxonomy, the publishing industry has been reclassified outside the manufacturing sector (in the Information and Cultural industries NAICS-511). Because publishing activities constitute an important share of the printing industry, we excluded the whole "Printing and Related Support Activities industry (NAICS-323 and NACE-22)" from both samples. It turns out that 244 observations (or 560 if we apply the raising factor, i.e. 6% of the whole sample) were removed from the Canadian sample. The corresponding figures for the four European countries are 295 for France, 44 for Germany, 21 for Ireland and 205 for Spain. NACE industry 37 (recycling) was also removed from our sample because the corresponding Canadian activity is partly assigned outside of manufacturing. Other discrepancies were considered as minor[4]. At the end, firms are aggregated into 10 industries with strong equivalence between classifications used (see appendix).

Target population (cut-off point)

*Canada:*To be able to link production data to innovation data, the sample for the innovation survey is drawn from respondents to the Annual Survey of Manufacturers –1997 (ASM) also conducted by Statistics Canada. Using ASM as the sample frame allows survey designers to reduce the response burden by coupling existing data on production (such as shipment, employment, wages and value added) to innovation data. It should be noted that ASM is considered as the manufacturing census.

There are two cut-off points in the Canadian innovation survey. Theoretically, each provincial-enterprise should have gross business income of at least $250,000 and more than 19 employees. However, due to a lack of reconciliation between the business register database and the ASM database, some firms with less than 19 employees (according to the ASM) were included in the

[4] For more details, see the document "Concordance of NAICS Canada 1997 to ISIC Rev3" at www.statcan.ca.

sample. There is no census above a certain threshold (such as in France – see below) meaning that firms, even the largest ones, could be excluded from the selected sample.

EU

The sample frame is the business register in France and Spain. In Germany, where there is no official register, the database of the most important German credit rating agency ("Verband der Vereine Creditreform") has been used as the sample frame. Some strata in Germany might be overrepresented. The sampling fractions are quite different across strata. In Ireland the database of enterprises maintained by Fórfas (the Policy and Advisory Board for Industrial Development in Ireland) has been used for the total population. The cut off point for inclusion in the target population is 10 employees (20 in Ireland).[5] There is no cut-off point on the level of turnover. The target population is based on a combination of census and sampling. The census is used down to a certain threshold – 500 in France, 200 in Spain -or if the total number of enterprises in the frame population in a certain industry and size stratum is below 5. In Germany, there is no census above a certain threshold.

To reconcile surveys

Remove from the sample in all countries observations with less than 20 employees or less than $250K in total revenue (for Canada) or less than Euro165K in total turnover (for European countries). 224 observations are removed from the Canadian sample, none in France, 6 in Germany 4 in Ireland an 8 in Spain.

Stratification and raising factors

Canada

To extrapolate results to the whole target population, raising factor have been calculated. The raising factors are based on ratios of the numbers of enterprises in the realized sample and the total number of enterprises in each province and industrial stratum (at 4 digit level) of the target population. The strata are defined by province and industry.

EU

In CIS2, the data are not weighted, but raising factors are provided in the dataset. In principle, if a non-response analysis is carried out, its results are used in the calculation of the weighting factors. Adjustments are supposed to be made for enterprises not found or no longer active. The stratification variables are industry and size. Industries correspond to 2-digit industries of NACE Rev.1 and size classes are recommended to be 10-19 (if below 20 cut-off point), 20-49, 50-99, 100-249 (if applicable), 250-499 (if applicable), 500-999 (if applicable).

[5] The microaggregated data we received from Eurostat were cut off at 20 employees.

To reconcile surveys

In both Canadian and European surveys only one raising factor is used for all variables. The analysis should be conducted on weighted or unweighted data in both countries. To assure a better representation of the industrial distribution of each country, weighted data will be used to analyze the firm's innovative performance.

Population, sample size, response rate (and non-response analysis)

Canada

From a population of 9,303 manufacturing provincial-enterprises 5,944 were sampled. The response rate was over 90 per cent. Because of the low percentage of non-response, no analysis has been done so far to interpret and analyze the behavior of non-respondents.

EU

In France, the population had 23,461 enterprises, the gross sample comprised 6,025 of them and there was a 85% response rate. In Germany, the figures are resp. 39,006, 6,258, and 29% (if we exclude enterprises with less than 20 employees), in Ireland, 1,872, 1,151 and 38%, and in Spain 18,811, 10,453 and 75%. A non-response analysis was carried out for Germany and Ireland. The microagregated dataset received from Eurostat contained 4,986 observations for France, 1,686 for Germany, 440 for Ireland and 4,763 for Spain. All observations with less than 20 employees were removed.

To reconcile surveys

In Germany and Ireland we have a much lower response rate than in Canada, France and Spain. In these two countries, the frame population is not drawn from the business register and (see below) the survey was not mandatory. We should at least be aware of this when drawing conclusions.

Comparisons regarding target population and sample for the 1999 Canadian Survey of Innovation and the second Community Innovation Survey are summarized in Table 1.

2.2 Survey Implementation

There are also some differences between the Canadian and the CIS2 surveys regarding the implementation of the survey. The main differences are the contact person, the reference year, the voluntary or mandatory nature of the survey, and the way in which the data are made available to outside researchers (see table 2).

In Canada, the CEO or a person designed by the CEO completed the survey. CEOs with more than one "provincial enterprise" were sent more than one questionnaire. In Europe, the questionnaire was supposed to have been sent to the *right* person (finding out who the responsible person is was done by phone). It was supposed to be the R&D manager for large enterprises and managing directors for small enterprises. There is no way we can know who exactly answered the questionnaire, nor would it be possible to correct for that.

In Canada the reference year was 1997-1999, in the European countries, 1994-1996. Even though the surveys do not cover the same years, it should not matter too much, at least for the highly innovating firms, which probably innovate all the time. Less-innovating firms might not innovate every year, but are likely to innovate at least once over three years. Product innovators are often process innovators and vice versa, hence innovations are often linked to the adoption of the latest technologies.

However widespread use of ICT in the last years, and its effect on the innovation process, may favor Canadian innovative performance over the European countries. As point out by the OECD (2000a): “diffusion of ICT accelerated after 1995 as a new wave of ICT (…) spread rapidly throughout the economy” (OECD, 2000a)and therefore, Canadian firms may have benefited from the extra-years covered by the Canadian survey.

For raison of data confidentiality Canadian data are made available by Statistics Canada in their raw form to approved researchers sworn in under the Statistics Act. The CIS2 data are made available in microaggregated form by Eurostat under restricted conditions but studies by Hu and Debresson (1999) and Mairesse and Mohnen (2001) show that results do not differ much if raw or microaggregated data are used.

The biggest difference in implementation probably has to do with the voluntary vs. mandatory nature of the survey. In Canada enterprises were obliged to respond to the survey, In the EU, it was mandatory in France and Spain, but voluntary in Germany and Ireland. There might be a selection bias operating when responses are voluntary, because firms that feel sufficiently innovative or that are sufficiently organized in their innovation activities, e.g. with record-keeping, are more likely to return the questionnaire.

2.3 Questionnaire

Definition of innovator

Innovation is defined in the Oslo Manual as technologically new or improved products or processes[6]. Questions 3-4 of the Canadian Survey correspond to variables INPDT and INPCS in CIS 2. These two criteria define an innovator in a broad sense. In the French, German and Irish surveys innovations are more clearly defined at the back of the questionnaire, sometimes examples are provided. In the Canadian questionnaire there is no example of “non-innovation”, but explanations are given such as “*Changes to your firm’s existing products which are purely*

[6] It should be noted that the term "technologically" has been dropped in the Canadian questionnaire.

aesthetic or which only involved minor modifications are not to be included" and "*Minor or routine changes to processes are not to be included*".

The Canadian questionnaire has a question about the number of product innovations (in brackets). The CIS2 questionnaire does not. However, the latter provides information on who introduced the new product or process (the enterprise itself, mainly other enterprises or both), the Canadian Survey does not. In Canada we have potentially a second criterion for identifying innovators, namely by the existence of any innovation activities (R&D, training, external technology acquisition, etc), i.e by the input side of innovation (question 6). For Europe, these data are available only for enterprises that declare to have introduced a new product or process.

Availability of data for non-innovators

In both surveys we have for all firms data regarding their industry affiliation, their size in numbers of employees (variable TOTEMP in the Canadian survey, variable EMP in CIS 2) and a dichotomous variable indicating whether size increased, decreased or remained the same during the relevant period (variable 28 in the Canadian survey and EMPC in CIS 2).

Only the Canadian Survey has, for all enterprises (not just innovators), information on the strength of competition and the firm success factors (both on a scale of 1 to 5, questions 1 and 2), on whether various innovation expenditures have been incurred (binary variable, question 6), on the presence of R&D activities, and whether R&D is internal or not, done continuously or occasionally (binary variables, question 24), on the use of intellectual property protection mechanisms (binary variable, question 25), on the number of patents applied for in Canada and in the United States (question 26).

CIS 2 only has information on whether the enterprise is independent or part of an enterprise group (GP), binary variables regarding changes occurred in the enterprise (new establishment (CHG_1), merger (CHG_2), closure (CHG_3)), the actual percentage change in the number of employees (EMPC), the change in turnover between 1994 and 1996 (TURNC), the export in 1996 (EXP), the change in export between 1994 and 1996 (EXPC), and the factors hampering innovation (see below).

There are very few variables commonly available in both surveys that could be used to discriminate between innovators and non innovators in a broad sense.

Amount of innovation

In Canada the percentage in sales of new or significantly improved products is only available in certain brackets (1%-5%, 6%-15%, 16%-25%, 26%-50%, 51%-75%, 76%-100%, question 12). In CIS2, it is available as a continuous variable (variables TURNNEW and TURNIMP).

To make the two surveys comparable, we could either in Canada assign the median sales share to each bracket or in the European countries construct brackets of shares in sales of innovative products. It would be worthwhile to check for European countries how the shares in sales of

innovative products are distributed (graph or quartile distribution) to see if categorical observations are not as informative as continuous numbers.

Novelty of innovation

In Canada, there is a distinction (in question 18) between a world-first innovation, a first in Canada, and a first for the firm. In CIS 2 we have data on technologically new or improved products *new not only to your enterprise but also to your enterprise's market* (variables INMAR and TURNMAR).

How is the market defined in CIS2? We think the idea is to distinguish between first for the firm and first outside the firm, hence we think that the union of first in Canada and world first is the nearest equivalent to TURNMAR. Perhaps we should use world-first as a lower bound and world-first plus Canadian-first as an upper bound for strict innovation in Canada. The notion of market might encompass more than just the national market, but not quite the whole world. In this paper, Canada-first and world-first innovation will be aggregated together to match the European definition of new to your enterprise's market. We call it first-innovation.

Unfortunately, the Canadian survey only reveals how many firms have introduced a first-innovation, not the share in sales of innovative products in the strict sense of first to the market. In CIS 2 we have data on the percentage of first-innovators (INMAR) and on the share in sales of innovative products in the strict sense of first-to-the-market products (TURNMAR). What we can do is limit the analysis to first-innovators and examine their share in sales of innovative products in the large sense.

Comparisons of Canadian and European questionnaires are summarized in Table 3. Other variables such as competitive environment, firm's success factors, sources of information, objectives of innovation, collaboration for innovation, obstacles to innovation, patent use and government support programs to innovation – are also included in the summary table.[7]

3. Results

To be able to use the data from the Canadian and the CIS2 surveys of innovation for international comparisons of innovative performance, we had to make a certain number of transformations of the data. First, we removed all observations with less than 20 employees or less than $250k (the rough equivalent of Euro 165k) of turnover[8]. Second, firms in the "publishing" industry were removed, as their international comparability was impossible. Third, raising factors, which are the inverses of the sampling rates per province and industry in Canada

[7] A more in-depth comparison of these variables is available on request.
[8] For Canadian data, total revenue has been used for the cut-off point.

and per size and industry in the European countries, were applied to the data in both countries to approximate the total population[9].

Before analyzing the results, it should be noted that the transformation of the raw data does not change or bias them in any systematic way. Official results from Eurostat (the statistical institute of the European Union) as well as results from Statistics Canada (the statistical institute of Canada) do not diverge significantly from our findings. The percentages of innovators in the broad sense or in the strict sense of first-innovators presented in this paper are close to those reported by Foyn (1999, 2000)[10].

Table 4 shows an important difference in the percentage of innovators (in a broad sense) across the five countries. The frequency of innovation was much higher in Canada in 1997-1999 than in the four European countries in 1994-1996. In Canada 80% of the sampled firms introduced a new or improved product during the 1997-1999 period. Ireland and Germany follow with respectively 74% and 68% of innovative firms in the realized samples. In France and Spain less than one half of the firms are innovative.

It comes as no surprise to notice that in all countries the highest percentage of innovators can be found in the high-tech sectors. The difference in innovative performance between countries is lower among enterprises in the high-tech sectors than among all firms. Canada still has the best performance with 88% of innovative firms but for the laggard Spain the proportion rises from 30% for the entire manufacturing sector to 55% in the high-tech sectors. Likewise, the difference in the percentage of innovative firms decreases substantially when we look at large firms only. The innovative performance is practically similar for Canada, Germany and Ireland (with respectively 88%, 86% and 85% of innovative firms). Large French and Spanish firms do not lag far behind with 77% of innovative firms in both countries. Canada's lead in the percentage of innovating firms is thus strongest in low-tech sectors and small firms.

What could explain the higher incidence of innovation in Canada? As noted before, the Canadian firms were surveyed in 1999, the European firms in 1997. Did the two-year lag matter? For firms in a low knowledge-intensive sectors, it may be important. As previously mentioned, the widespread diffusion and decreasing cost of information and communication technologies (ICT) in the last few years, may have favored the innovative performance of Canadian firms, in particular the less technologically-intensive industries[11]. Indeed, as shown in Table 4, Canadian firms in low-tech industries are closer to the national average (77% vs. 80%) than low-tech firms in other countries. As we mentioned before, the use of the provincial enterprise as a statistical unit and the resulting multiple appearance of a multi-location firm in the Canadian survey did not

[9] The raising factors are not perfect. First of all there is only one raising factor per enterprise and not a separate raising factor per variable and enterprise. Second, as we have eliminated a number of observations the raising factors should be recomputed but we do not have the appropriate information to do so.

[10] Foyn (1999, 2000) reports only for European countries. For Canada, the percentage of innovators does not significantly change using the official results over the results presented here (see section 2). In the same manner, there is virtually no change using the sub-sample of single-location firms (25% of first-innovators) or the whole Canadian sample (26%).

[11] But it should also be noted that, already in 1996, the price of ICT investment was lower in Canada than in other European countries (OECD, 2000b).

lead to any serious bias. Perhaps the ordering of the questions, starting with a series of questions making the respondent aware of his being innovative, and the insistence of having the CEO to answer the questionnaire also contributed to increasing the rate of self-declared innovators in Canada. Moreover, adding the term "technologically" to the European definition of innovation may have created some confusion and reduced the percentage of innovative firms in European countries[12].

The higher incidence of innovators in Ireland and Germany compared to France and Spain could be partly attributed to a sample bias. The Irish and German surveys were non-mandatory (responded to on a voluntary base), which could have lead to an over-representation of innovative firms. Non-innovative firms are less likely to answer a questionnaire on innovation. Guellec and Pattinson (2001) notice a negative correlation between response rates and innovation rates.

Another innovation indicator, the percentage of innovative sales in table 5 (using only the sub-sample of innovating firms) reveals quite a different pattern. Germany and Spain were very successful in collecting revenue from innovation[13]. On average, innovation resulted in almost 50% of new sales for innovative firms in these two countries. Ireland follows with 37%, but Canada and France trail with 27%. While Canada was first in innovation frequency, it ranked last in innovation intensity.

Again firms in high-tech industries outperformed firms in other industries, in all countries. The share in sales of innovative products is not necessarily related to the size of the firm. Small firms in Germany reached, on average, a larger part of innovative revenue than larger firms. Difference between small and medium-sized firms (50-250 employees) is statistically significant implying that small firms in Germany appropriated a larger share of revenue from innovation than medium-sized firms[14]. For Canadian firms, differences in size did not make a difference in turning innovation into revenue. In Spain, Ireland and France, larger firms tended to have a larger share of their sales in innovative products.

So far, we have used a large definition of innovation, i.e. firms introducing a new or improved product on the market, be it new to the firm or new to the market. It would be interesting to focus on real inventors or what we called first-innovators. In the CIS 2 questionnaire, a distinction is made about the novelty of the innovation — namely a product new to the firm versus one new to the market. In Canada, an innovation could be a first-in-the-firm, a Canada-first or a world-first. To compare Canadian data to European data, we merged World-first and Canada-first innovations and considered the two of them together as the nearest equivalent to the notion of new to the market used in the European surveys.

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[12] See Eurostat (2000), or Guellec and Pattinson (2001) for more details.

[13] When aggregating the shares in sales of innovative products, we take a weighted average of the declared figures reported in the survey, the weights being the relative sales in the respective samples. For the CIS 2 data we also apply the firm's weighting factor to approximate the total population. For Canada, we take the median value of each bracket and compute an average for each industry. We compute the weighted average using the relative sales of 1997 (beginning of the period studied).

[14] However, the difference is not statistically significant between small (20-49 employees) and large firms (more than 250 employees). Chi-square tests (α=5% and 1%) have been done.

Results from Table 6 show that the percentage of first-innovators in Ireland, Canada and Germany is practically similar at respectively 27%, 26% and 25%. France and Spain lag behind with respectively 21% and 11% of first-innovators. However, the sub-sample of innovators in the broad sense reveals another trend (compare the totals in tables 4 and 6). France produces the largest proportion of first-innovators by pool of 100 innovators. France produces 48 first-innovators by 100 innovators, while Germany , Ireland and Spain produce respectively 37, 36 and 36 % of first-innovators[15]. Canada generates 33 first-innovators by 100 innovators. The latter result tells us that even though Canada has been successful in providing a successful environment for the diffusion of technology, Canada has failed to provide a flourishing environment for breakthrough innovation. In France and Spain innovations do not seem to be as widespread in the economy as in Canada, but if a firm is innovative in these two countries, the likelihood of a breakthrough innovation is much greater than in Canada.

Table 6 also shows that size matters, as larger firms are more frequently first-innovators than smaller ones. As stated before, ICT has reduced the cost of codifying and diffusing information, which would leave more room for small firms to innovate (lower cost to innovate). However, results from Table 6 show that smaller firms have not yet benefitted from these new opportunities as they are still less likely (whatever the country) to introduce first-innovations.

Finally, looking in table 7 at the percentage of sales from innovative products in the broad sense for first-innovators shows approximately the same trend as observed in the whole population of innovators. German firms are the ones that reach the greatest share in revenue from innovative products with 54%. Spain follows with 47%, then Ireland with 43%, Canada with 35% and France with only 31% of sales from innovative products. For all countries, the percentage of revenue from innovation is greater for the sub-sample of first-innovators than for all innovators. However, this fact does not mean that first-innovators reach more revenue from the creation of technology (as opposed to the adoption of technology) but only that first-innovator are more likely to capture revenue from their innovation activities.

4. Conclusion

We have compared the Canadian and CIS 2 innovation surveys in terms of design, implementation and formulation of the questionnaire. We have pointed out a number of differences and tried to assess their possible effect on the interpretation of the data. We have also as much as possible harmonized the two datasets to make them sufficiently comparable. Finally, we have looked at four innovation indicators and compared Canada with four European countries (France, Germany, Ireland and Spain) in innovation performance in regard to these four indicators.

Canada leads the pack by far if we consider the percentage of innovating firms in the respective country samples, however it ranks last if we consider the share in sales of innovative products. It

[15] According to Table 4 and 6, France has 4542 first-innovators (21%) among 9613 innovators (44%), which represents 47% of first-innovators in the sub-population of innovators. The same calculations have been done for the remaining countries.

is also among the best, but no longer outdistancing them, if the criterion of performance is the percentage of first-innovators, and again it trails if the criterion is the share of innovative sales among first-innovators. Unfortunately, quantitative data on the share of sales specifically due to first-innovation is not available in Canada.

There is some common trend in all countries: Firms in high-tech sectors are more frequently innovative and reach a greater share of revenue from innovation than firms in other sectors. Large firms are more often innovative but size is not always a good predictor for the percentage of revenue from innovation.

Canada, Germany and Ireland seem to be relatively similar regarding the percentage of first-innovators. France and Spain lag behind but seem to have a high intensity of first-innovators among the sub—population of innovators in the broad sense.

These first descriptive statistics already point out the role of firm size, industry specificities, and possibly response rates and time-frame. To understand better why performances differ across countries, it will be interesting and necessary to investigate in greater depth the data on hand using econometric techniques. It is hoped that some explanations to international differences can be obtained by controlling for some possible explanatory variables, such as size, degree of competition, or R&D efforts. Of course, as the initial comparison of available explanatory variables in the two datasets (the Canadian and CIS 2) shows, there are only a limited number of explanatory variables that we can bring forward at this stage to deepen our understanding of innovation. But at least it is worth a try.

Appendix

Tables of concordance between NAICS and NACE (rev. 1) industrial classifications by industry and by technological intensity

Aggregation by industry:

NAICS code	NACE code (rev. 1)	Corresponding economic activities
311-312	15-16	Food, beverage and tobacco products
313-316	17-19	Textile mills, textile product mills, clothing, leather and allied products
321-322	20-21	Wood products and paper manufacturing
324-325	23-24	Coke and Chemicals products
326-327	25-26	Rubber and other non-metallic products
331-332	27-28	Basic & Fabricated metal products
333	29	Machinery and equipment
334-335	30-33	Electrical and optical equipment
336	34-35	Transport equipment
337+339	36	Furniture and related products and miscellaneous manufacturing

Aggregation by technological intensity*:

NAICS code	NACE code (rev. 1)	Corresponding economic activities
		Low-technology
311-312	15-16	Food, beverage and tobacco products
313-316	17-19	Textile mills, textile product mills, clothing, leather and allied products
321-322	20-21	Wood products and paper manufacturing
		Medium-technology
324	23	Petroleum and coal products
326-327	25-26	Rubber and other non-metallic products
331-332	27-28	Basic & Fabricated metal products
333	29	Machinery and equipment
334.5-334.6	33	Navigational, medical, medial and optical equipment
336.1-336.3	34	Motor vehicles, trailers and semi-trailers
337+339	36	Furniture and related products and miscellaneous manufacturing
		High-technology
325	24	Chemicals and chemical products
334.1	30	Computers and peripheral equipment
334.4+335	31	Electrical and electronic machinery and equipment
334.2-334.3	32	Radio, television and communication equipment and apparatus
336.4-336.9	35	Aerospace products and parts, and other transport equipment

*: Taxonomy is drawn from Hatzichronoglou (1997).

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Table 1 Target population and sample

	Canada	**CIS 2**
Statistical unit	Provincial-enterprise	In principle, enterprise
Industrial classification	NAICS	NACE (rev. 1)
Target population (cut-off point, threshold for census)	1. 19 employees 2. $250 Gross business income ($GBI)	1. 19 employees 2. no threshold for $GBI
Origin of the sample frame	Canadian Annual Survey of Manufacturers	Business register in France and Spain, database of a credit rating agency in Germany, database of Fórfas in Ireland
Stratification and weighting factors	By industry and province	By industry and size
Response rate	90%	85% in France, 75% in Spain, 29% in Germany, 38% in Ireland
Non-response analysis	No	Yes in Germany and Ireland
Realized sample size (without publishing ind. and without < 20 employ.)	4,984 observations	4,986 in France, 1,686 in Germany, 440 in Ireland, 4,763 in Spain

Table 2 Implementation

	Canada	**CIS-2**
Contact person	CEO	R&D manager or managing director
Institute responsible for the survey	Statistics Canada	National statistical institutes, ministries, research institute or industrial advisory board
Reference year	1997-1999	1994-1996
Voluntary – mandatory	Mandatory	Mandatory in France and Spain, voluntary in Germany and Ireland
Availability of data for researcher	Micro-data available if research proposal accepted	Microaggregated data made available to approved researchers by Eurostat

Table 3 Questionnaire

	Canada	**CIS 2**
Definition of innovator	New or improved product/process	Technological new or improved product/process
Data available for non-innovators	Industry, size, dummy on size growth Strength of competition, firm's success factors, innovation expenditures, R&D, use of intellectual property conditions, patents, government support programs	Industry, size, dummy on size growth Independence, changes occurred to enterprise, , growth in turnover, exports, growth in exports, factors hampering innovation
Amount of innovation	in brackets	continuous
Novelty of the innovation	Three levels of novelty: 1. World-first innovator 2. Canada-first innovator 3. Firm-first innovator No share in sales of innovative products for 1 and 2, only for 3	Two levels of novelty: 1. New to the firm 2. New to the firm's market Share in sales of innovative products for 1 and 2
Types of innovation	Separate dummies for process innovations and product innovations Share in sales for product innovations only Impact of product and process innovations	Separate dummies for process innovations and product innovations Share in sales for product innovations only
Competitive environment	YES	NO
Firm's success factors	YES	NO
Innovation activity	5 activities Binary information only For all enterprises	7 activities. R&D split in internal and external. Quantitative information For innovators only
Sources of information	16 sources binary	12 sources scale of 1 to 3
Objectives of innovation	16 objectives scale of 1 to 5	10 objectives scale of 1 to 3
Obstacles to innovation	14 factors For innovators only No filter	9 factors For all enterprises Three filter questions
Collaboration for innovation	3 set of questions: 1- reasons to collaborate 2- type of partners 3- location of partners	2 set of questions: 1- type of partners 2- location of partners
Patent use	All enterprises Dichotomous variable and number of patents	Only innovators Dichotomous variable
Government support programs	All enterprises	Only innovators

Table 4 Percentage of innovators (broad sense) – nb of observations in the population

	CANADA		FRANCE		GERMANY		IRELAND		SPAIN	
	%	Obs.	%	Obs.	%	Obs.	%	Obs.	%	Obs.
FOOD	0.80	878	0.45	3,108	0.67	4,022	0.66	330	0.22	3,093
TEXTILE	0.75	835	0.30	3,085	0.62	2,387	0.58	188	0.18	3,066
WOOD	0.75	950	0.40	1,267	0.47	2,300	0.68	92	0.23	1,260
COKE	0.86	473	0.68	1,166	0.75	1,312	0.79	161	0.62	927
RUBBER	0.80	853	0.49	2,273	0.67	4,685	0.79	192	0.31	2,450
BASIC M	0.76	1376	0.31	4,638	0.59	6,487	0.68	213	0.25	2,685
MACHIN	0.87	824	0.63	2,059	0.83	5,582	0.89	100	0.46	1,281
COMPUT	0.92	487	0.61	2,204	0.78	4,145	0.87	282	0.56	937
VEHIC	0.80	434	0.49	793	0.71	1,035	0.88	64	0.46	642
FURNIT	0.82	863	0.38	1,133	0.67	2,127	0.70	122	0.24	1,294
LOW	0.77	2,663	0.38	7,458	0.60	8,710	0.64	610	0.20	7,419
MED	0.81	4,386	0.44	11,542	0.71	21,430	0.78	752	0.32	8,313
HIGH	0.88	925	0.62	2,725	0.74	3,942	0.82	383	0.55	1,902
20-49	0.75	2,379	0.35	11,783	0.63	14,842	0.69	923	0.22	12,374
50-249	0.81	4,457	0.50	7,892	0.69	14,744	0.78	694	0.44	4,481
>250	0.88	1,137	0.77	2,050	0.86	4,496	0.85	128	0.77	779
TOTAL*	0.80	7,975	0.44	21,725	0.68	34,082	0.74	1,745	0.30	17,634

* Differences in the totals of Table 4 and those reported in the text (p.7-8) are due to the elimination of enterprises in Printing industry.
Source: Canada: 1999 Survey of Innovation, Statistics Canada; EU: CIS 2, Eurostat.

Table 5 Share in sales of new or improved products – number of innovators

	CANADA		FRANCE		GERMANY		IRELAND		SPAIN	
	%	Obs.	%	Obs.	%	Obs.	%	Obs.	%	Obs.
FOOD	0.19	637	0.12	1,411	0.29	2,712	0.15	217	0.37	673
TEXTILE	0.33	543	0.25	912	0.52	1,471	0.44	109	0.39	561
WOOD	0.24	535	0.24	505	0.30	1,076	0.20	63	0.47	284
COKE	0.20	361	0.23	793	0.39	977	0.28	127	0.34	570
PLASTIC	0.29	608	0.27	1,106	0.49	3,156	0.28	151	0.46	767
BASIC M	0.23	813	0.20	1,428	0.33	3,854	0.34	146	0.38	680
MACHIN	0.33	626	0.32	1,296	0.45	4,658	0.45	89	0.61	589
COMPUT	0.58	418	0.45	1,340	0.60	3,235	0.69	247	0.60	522
VEHIC	0.26	302	0.31	391	0.67	736	0.20	57	0.69	296
FURNIT	0.30	620	0.37	430	0.56	1,423	0.38	85	0.47	306
LOW	0.22	1,715	0.15	2,828	0.33	5,258	0.17	389	0.39	1,518
MED	0.25	3,017	0.27	5,090	0.49	15,127	0.32	587	0.53	2,678
HIGH	0.40	733	0.35	1,695	0.55	2,913	0.57	314	0.46	1,052
20-49	0.26	1,521	0.20	4,099	0.50	9,290	0.25	641	0.38	2,662
50-249	0.28	3,069	0.25	3,930	0.42	10,141	0.35	540	0.41	1,983
>250	0.27	875	0.28	1,584	0.49	3,867	0.42	109	0.51	603
TOTAL*	0.27	5,464	0.27	9,613	0.48	23,298	0.35	1,290	0.48	5,248

* Any discrepancy between the totals reported in table 5 and those that we would obtain by applying the percentages of innovators to the number of firms in Table 4 are due to rounding errors. For Canada, the difference is also due to the fact that the share in sales of innovative products is reported for product innovators only – excluding process innovators. Moreover, some Canadian innovative firms did not answer the question regarding sales resulting from innovation. Therefore, we excluded them to focus the analysis on firms which answered that question.
Source: Canada: 1999 Survey of Innovation, Statistics Canada; EU: CIS 2, Eurostat.

Table 6 Percentage of first-innovators – number of observations

	CANADA		FRANCE		GERMANY		IRELAND		SPAIN	
	%	Obs.*	%	Obs.	%	Obs.	%	Obs.	%	Obs.
FOOD	0.22	794	0.13	3,107	0.17	4,022	0.29	330	0.08	3,093
TEXTILE	0.20	727	0.14	3,085	0.33	2,387	0.11	188	0.05	3,066
WOOD	0.17	880	0.16	1,267	0.14	2,300	0.16	92	0.07	1,260
COKE	0.33	434	0.33	1,166	0.28	1,312	0.23	161	0.29	927
PLASTIC	0.31	781	0.26	2,273	0.23	4,685	0.25	192	0.09	2,450
BASIC M	0.20	1286	0.14	4,638	0.15	6,487	0.28	213	0.08	2,685
MACHIN	0.35	737	0.36	2,060	0.38	5,582	0.34	100	0.20	1,281
COMPUT	0.46	440	0.33	2,204	0.38	4,145	0.47	282	0.27	937
VEHIC	0.31	400	0.28	793	0.34	1,035	0.21	64	0.20	642
FURNIT	0.26	748	0.18	1,133	0.19	2,127	0.14	122	0.09	1,294
LOW	0.20	2,400	0.14	7,458	0.20	8,710	0.22	610	0.06	7,419
MED	0.28	3,982	0.23	11,542	0.26	21,430	0.26	752	0.12	8,313
HIGH	0.38	843	0.32	2,725	0.30	3,942	0.38	383	0.25	1,902
20-49	0.17	2,110	0.15	11,783	0.20	14,842	0.23	923	0.07	12,374
50-249	0.27	4,058	0.23	7,892	0.24	14,744	0.28	694	0.18	4,481
>250	0.40	1,057	0.44	2,050	0.47	4,496	0.52	128	0.40	779
TOTAL	0.26	7,226	0.21	21,725	0.25	34,082	0.27	1,745	0.11	17,634

* Some innovative firms did not answer the question regarding the novelty of innovation. Therefore, we excluded them to analyze results only on firms which answered that question.
Source: Canada: 1999 Survey of Innovation, Statistics Canada; EU: CIS 2, Eurostat.

Table 7 Share in sales of new or improved products for first-innovators – number of first-innovators

	CANADA (1st to the market)		FRANCE		GERMANY		IRELAND		SPAIN	
	%	Obs.	%	Obs.	%	Obs.	%	Obs.	%	Obs.
FOOD	0.19	172	0.17	400	0.41	670	0.17	97	0.35	232
TEXTILE	0.34	132	0.34	423	0.62	778	0.49	20	0.48	156
WOOD	0.28	133	0.25	207	0.32	331	0.22	15	0.56	90
COKE	0.22	128	0.26	386	0.34	364	0.39	38	0.34	270
PLASTIC	0.29	224	0.32	596	0.53	1,084	0.32	47	0.50	217
BASIC M	0.18	236	0.24	645	0.46	963	0.33	59	0.59	216
MACHIN	0.36	250	0.34	736	0.43	2,122	0.46	34	0.63	255
COMPUT	0.63	199	0.50	720	0.64	1,555	0.73	134	0.60	257
VEHIC	0.41	114	0.30	226	0.70	347	0.46	14	0.65	127
FURNIT	0.34	174	0.38	204	0.57	414	0.57	18	0.55	121
LOW	0.24	438	0.20	1,029	0.42	1,779	0.19	133	0.39	478
MED	0.31	1,026	0.29	2,630	0.53	5,657	0.38	199	0.51	988
HIGH	0.53	301	0.40	883	0.59	1,193	0.69	144	0.46	475
20-49	0.29	343	0.29	1,804	0.58	3,001	0.30	213	0.52	819
50-249	0.30	1,024	0.31	1,836	0.52	3,474	0.46	197	0.47	812
>250	0.36	398	0.31	902	0.54	2,154	0.47	66	0.47	310
TOTAL	0.35	1,765	0.31	4,542	0.54	8,629	0.43	476	0.47	1,941

Source: Canada: 1999 Survey of Innovation, Statistics Canada; EU: CIS 2, Eurostat.

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