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# Innovation Analysis Bulletin

**A tri-annual report from Statistics Canada with updates on:**

- **Government science and technology activities**
- **Industrial research and development**
- **Intellectual property commercialization**
- **Advanced technology and innovation**
- **Biotechnology**
- **Connectedness**
- **Telecommunications and broadcasting**
- **Electronic commerce**

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## Innovation analysis bulletin

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Editor: Michael Bordt

*E-mail:* *Michael.Bordt@statcan.ca*
*Telephone:* *(613) 951-8585*
*Fax:* *(613) 951-9920*
*Post:* *SIEID*
*Statistics Canada*
*7th Floor R.H. Coats Building*
*Tunney's Pasture*
*Ottawa, Ontario*
*Canada K1A 0T6*

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## Note of appreciation

Canada owes the success of its statistical system to a long-standing partnership between Statistics Canada, the citizens of Canada, its businesses, governments and other institutions. Accurate and timely statistical information could not be produced without their continued cooperation and goodwill.

## Symbols

| | |
|---|---|
| . | not available for any reference period |
| .. | not available for a specific reference period |
| ... | not applicable |
| p | preliminary |
| r | revised |
| x | suppressed to meet the confidentiality requirements of the *Statistics Act* |
| e | estimated figures |
| E | use with caution |
| F | too unreliable to be published |

## Downloadable publications

To obtain PDF versions of the papers and questionnaires mentioned in this bulletin, please visit the Statistics Canada Internet site:

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     Documents are under the categories: *Science and Technology* and *Communications*

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     Documents are under the category: *Science and Technology* and *Communications*

  3. *Research papers (free)*

     Our documents are in the category *Science, Innovation and Electronic Information Division*. This page contains a list of all free research papers, and working papers.

- Sample questionnaires are in the section
  - *Statistical Methods* in the area
    - *Questionnaires* under
      - *Science Innovation and Electronic Information*.

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## Get connected with us

Besides the articles to which we refer in this bulletin, Statistics Canada's Web site provides a wealth of statistics, facts and research papers on a variety of related topics. As well, most of the questionnaires we have used to collect the information are available for research purposes.

As of January 2002, there were:

- 11 publications for sale
- 4 free publications
- 12 research papers,
- 53 working papers, and
- 29 questionnaires.

# We have learned a great deal!

Innovation, e-commerce, emerging technologies, Internet use, the telecommunications industry, R&D and commercialization are discussed even more frequently in the media and in policy debates now than they were when the *Innovation Analysis Bulletin* began in the summer of 1999. This, the first issue of 2002, is an opportunity to recapitulate some of the findings that we have reported over the past seven issues. We have asked Dr. Fred Gault, Director of Statistics Canada's Science, Innovation and Electronic Information Division to summarize Statistics Canada's findings on these topics.

*Innovation Analysis Bulletin*: Dr. Gault, with innovation, the new economy and the networked economy all being discussed as much as they are, what has Statistics Canada been doing to inform these debates?

*Fred Gault*: Statistics Canada has been at the forefront of developing information on innovation and connectedness for over five years now. During this time, we have developed conceptual frameworks and conducted surveys on many emerging subjects: innovation, advanced technologies, emerging technologies, e-commerce, Internet use, and intellectual property management. One challenge in our occupation as official statisticians is to recognize when our surveys and analyses have led to a new understanding of the way things work.

*IAB*: How is this information being used?

*FG*: It depends on the client. With some clients, we are involved at the inception of research projects. This allows us to help formulate research questions that *can* be answered and it gives us a much better idea of what type of information is required. When we participate in the research, we learn. Some clients simply ask for data—their research questions are already established. In this case, the data sometimes don't fit the questions. Other users need help with interpreting our data and analytical findings. For them, our working papers and this *Bulletin* are the most useful sources of information.

*IAB:* With so much data and so little time, it must be a challenge to get the best use out of the information that you have.

*FG*: We have many analysts at Statistics Canada working on these topics. Readers of the *Bulletin* will be familiar with their work. The analysts, however, are also responsible for managing the surveys and producing initial results. That doesn't always leave time for reflecting on the results and providing higher-level interpretation. We do engage visiting researchers and they contribute to our research paper series. Recently, we co-hosted a workshop with Industry Canada to discuss *Measuring Innovation*. It was a unique opportunity to bring together analysts and researchers from around Canada and some from outside Canada to develop a common understanding of findings from this important series of surveys. It was an excellent initiative on the part of Industry Canada.

*IAB*: These workshops, research papers and working papers constitute a unique source of knowledge about science, innovation and electronic information. What are some of the findings?

*FG*: There are so many, I'll have to list them by category:

## Innovation

A majority of companies innovate. That is, they put new products on the market or they introduce new processes in the way they make their products. For selected service industries in 1996, innovation rates ranged from 35% for scientific and technical services industry to 85% for telecommunications services. The rate of innovation was also high for manufacturing industries in 1999—80% of whom reported innovations.

Only a small proportion of the innovations is actually "world first". For example, in 1999 CEOs in innovative manufacturing firms that described their most important innovation indicated that 12% of these innovations were "world firsts".

The volatility (proportion of firms either starting or closing) of information-intensive industries (advertising and computer services) was almost double that of the knowledge-intensive service industries (accountants, architects and engineers) in 1996. This can be largely attributed to the human capital cost of entering or leaving a professional service.

In the engineering services industry, almost 41% of the firms reported introducing an innovation during the previous three years. Larger firms had higher rates of innovation than smaller firms did. In this industry, the most important sources of ideas for new innovations were clients, in-house R&D and the company's own management. Companies cited high risks of failure to develop a product and the high risk of a product failing on the market as the key barriers to engaging in innovation.

Knowledge-intensive firms in engineering services tend to be more innovative than firms with less knowledge capacity (measured in terms of the proportion of employees with conceptual versus implementation skills). Those with less knowledge capacity still managed to innovate but tended to hire specialists for specific complex tasks.

Organizational change is far less common (16%) than product or process innovation in the engineering services industry but it is frequently accompanied by or leads to other types of innovation.

In spite of the gains in operational efficiency from innovations in processes and delivery of services, the net effect of innovation is to increase jobs. About one-third of the innovating engineering services firms reported an increase in jobs with only 4% reducing jobs; the remaining 63% experienced no change in labour requirements.

International borders do not appear to be a barrier to technology flows but innovations first introduced in foreign countries take almost twice as long to adapt and implement than those adapted from other firms in Canada.

## R&D

We are playing a major role in tracking Canada's R&D objectives. The main indicator that shows our ranking in terms of R&D intensity is Gross Domestic Expenditures on R&D (GERD) divided by GDP. Canada's level increased from 1.5% in the early 1990s to 1.6% in the mid-1990s. In 2000, we reached 1.8%. Although our GERD has been growing faster than our GDP, the GERD in many of the other OECD countries to which we compare ourselves is growing even faster.

The Federal Government's role in R&D has been shifting from performing R&D to funding R&D in the private sector and universities. Between 1997 and 2001 the proportion of the federal government's budget dedicated to R&D increased from 2.1% to 2.8%. In 1996, 63% of the federal government's R&D expenditures were on activities conducted in-house. By 2001, this proportion had dropped to 52%.

In 1996, the service sector (including government and universities) accounted for 67% of GDP and 60% of Canada's expenditures on R&D.

Canada's tax incentives for R&D are the most stable and generous in the world.

## Biotechnology

Respondents participating in the first biotechnology use survey in 1996 identified several barriers to the adoption of biotechnology. These included high equipment costs and government regulations.

Comparing biotechnology firms that are growing rapidly with those that are growing more slowly suggests that: patenting is crucial to obtaining venture capital; diversifying R&D into several products at once minimizes risks; it pays to target the export market; and venture capital and well-timed alliances contribute substantially to growth.

In 1997, 85 large firms conducted R&D in biotechnology. The biotechnology R&D expenditures grew from $89 million in 1989 to $446 million in 1997. Over this period, the share of Canadian-controlled biotech R&D companies increased from 65% to 69%.

In 1999, biotechnology accounted for 11% of the revenues of the 358 firms that used biotechnology. Biotechnology revenues were reported to be $1.9 billion, and increase of 25% over the previous year. Expectations were that these revenues would increase to $5 billion by 2002. The most important obstacles to commercializing biotechnology products were lack of access to capital as well as time and cost constraints.

SIEID has also tracked the federal government's activities in biotechnology S&T for the past three years. In 1999-2000 expenditures amounted to $400 million.

## Collaboration

Based on work that we supported, we know that the level of collaboration in publishing scientific papers increased greatly between 1985 and 1995. Quite definitely, access to the Internet and its collaborative tools have played a major role.

One-third of innovative manufacturing firms in Canada develops new products and processes in collaboration with partners. Firms tend to collaborate with nearby public sector partners. They tend to collaborate with private sector partners irrespective of distance.

## Advanced technologies and practices

Advanced technologies are being adopted by construction and related industries. Forty-six percent of the businesses used at least one advanced communications technology; one in four used advanced on-site technologies and one in five used new materials. The most common advanced practices are design-build

contracts, computerized inventory and computerized estimating software.

## Connectedness

The use of information and communication technologies (ICTs) is often attributed to the long period of economic growth that Canada experienced until recently. With the burst of the "dot-com" bubble, much of this exuberance, particularly related to electronic commerce, has evaporated. The 2000 Survey of Electronic Commerce and Technology provided some important insights on these activities. In 2000, private-sector Internet sales rose sharply by 73% from the previous year. Despite this large year-over-year increase, the percentage of enterprises selling online declined from 10% to 6%. Notwithstanding this decline, the proportion of economic activity attributable to businesses that sold over the Internet was 25% in 2000, increasing from 17% in the previous year. We saw electronic commerce becoming concentrated into fewer, larger businesses.

The implications of this are important. Larger, more organized businesses seem to be taking control of the e-commerce marketplace, displacing smaller players. The growing level of sales hid the apparent volatility among players.

Households are also a key part of the digital economy. Estimates of Internet use by households, based on the Household Internet Use Survey (HIUS) revealed that Internet use took its biggest jump ever in 2000. This dampened speculation that the Internet's popularity was levelling off. The percentage of Canadian households with at least one member who was a regular Internet user advanced to 51% in 2000 from 42% the previous year. The survey also revealed that in 2000, households accessed the Internet more frequently and were staying online longer compared to previous years.

With the strong increase in the number of households using the Internet, the value of orders placed over the Internet from home advanced sharply in 2000. Orders placed over the Internet were valued at $1.1 billion, rising from $417 million in 1999.

More importantly, we are seeing a shift in the use of the Internet from a vehicle to assist households in making purchasing decisions to a means of completing commercial transactions. The number of households making purchases online now exceeds the number of "window-shopping" households.

Cycle 14 of the General Social Survey measured individual, as opposed to household, use of the Internet. This survey found that in 2000, Internet users were generally younger, had a higher income and were more educated than non-users. The survey also found that adults who banked or placed orders over the Internet tended to be in their late 20's and 30's. Furthermore, men were more likely to purchase goods and services over the Internet.

## Telecommunications and broadcasting

The pace of change in the telecommunications industry has not let up since the first *Innovation Analysis Bulletin*.

We have watched the growth of the cellular telephone industry quadruple from just over one million subscribers in 1993 to over 4 million in 1997, and double again by the second quarter of 2001 (9.5 million). Despite this rapid increase, there were no signs of slowing in the number of wireline subscribers.

Digital mobile telephony overtook analogue transmission in the fourth quarter of 2000. In the second quarter of 2001, just over 58% of subscribers receive digital services. Digital mobile transmission technology allows greater voice clarity and enhanced services such as mobile Internet browsing. Nearly all wireline access (99.6% of the public switched telephone network) is already digital.

Foreign-ownership is a prominent characteristic of companies providing reselling of telecommunications services.

The cable industry is going through significant market and technological changes. In 2000, the number of subscribers to cable television services decreased marginally, the first decline in the industry's history. During that period, subscriptions to the programming services of satellite and MDS operators grew by 75% to reach one million. The market share of satellite and MDS operators grew to 10.8% in less than 3 years.

While faced with increased competition in their traditional market, cable operators have embraced new technologies and positioned themselves as major players in the Internet access service market. First launched in late 1996, high speed Internet access by cable was available to 7.5 million households in August 2000, or 68% of households with access to cable. However, access varied considerably by size of community; 83% within census metropolitan areas, 47% within census agglomerations and 14% elsewhere.

Digital television is another technology gaining ground. At the end of August 2000, cable operators had deployed 390,800 digital terminals and wireless operators had deployed 967,800. This suggests that Canada is moving towards the critical mass of digital television customers necessary to make the television set a viable alternative to the computer for selected Web applications.

Much has been said about the convergence of media. The proportion of conventional broadcasters that integrate the Web in their business model is an indication of such convergence. In

2000, close to 70% of conventional broadcasting enterprises operated a Web site and 30% of those operating a Web site used it to generate revenues.

## Intellectual Property

In 1999, Canadian universities held 1,836 patents after having added 325 that year. The federal government held more patents (1,946) but the rate of increase was lower (89 in 1999).

In addition, in 1999, the federal government initiated 191 new licenses, 84% of which were with Canadian companies. Canada's universities reported 218 new licenses but only half of these were with Canadian companies.

## Human Resources

Many Canadian students lose interest in science and math between Grades 4 and 8. This lack of interest is even more pronounced in the last year of high school. Only 42% of these students were enrolled in both science and math courses in 1995. Regardless of this drop in interest and participation, Canadian students continue to perform very well in international mathematics and science performance assessments.

Other than the large numbers of science graduates taking advanced degrees in business, once a graduate has received a bachelors degree in sciences, it is likely that advanced studies will also be in the sciences.

Between 1991 and 1996, the number of people in Canada with S&T degrees grew by almost 18% to about 5 million persons. This rate of growth was almost five times higher than non-S&T degree holders. Industries with the highest concentration of S&T degree holders are health sciences, business services and construction.

1990's Bachelor's graduates in computer science and health care as well as Ph.D. graduates in pure and applied sciences by 1995 were more successful in terms of earning levels and job satisfaction than their counterparts in other fields of study.

In 1998, two-thirds of the companies that used advanced technologies reported shortages in experienced workers. For professional occupations, the greatest shortages were for industrial and manufacturing process engineers, and electronic engineers. Small establishments face the greatest challenge with skill shortages and are the least likely to overcome the challenges.

*FG:* Besides that, we have learned a great deal about how to conduct surveys on these emerging topics. In many cases, Canada is seen as the pioneer and our surveys are used as examples in many other countries.

*IAB*: Thank you very much, Dr. Gault. We're sure our readers will appreciate such a succinct summary of this vast amount of new knowledge that your Division and its collaborators have created.

*These findings were published in previous issues of the* ***Innovation Analysis Bulletin****.*

*Further information: Michael Bordt, SIEID, Statistics Canada, (613) 951-8585, Michael.Bordt@statcan.ca.*

# IP protection practices by manufacturing firms

The Statistics Canada ***Survey of Innovation 1999*** asked several questions on the protection of intellectual property. These questions enable researchers to determine how intellectual property rights (IPRs) use is related to the characteristics, activities, competitive strategies and industry sector in which these manufacturing firms operate. Related questions that were also addressed include the extent to which firms patent in Canada and abroad—especially in the United States.

*The author of this article, Petr Hanel, is with the Université de Sherbrooke and Centre interuniversitaire de recherche sur la science et technologie, CIRST. The work was conducted as part of SIEID's Facilitated Access program.*

The use of IPRs is to a great extent correlated with basic economic characteristics of firms, their activities and industrial environment. The survey sampled firms with gross business income over $250 000 and employing more than 20 persons. Most of the firms (80.7%) had introduced a new or improved product or production process, i.e., they innovated. Firms that innovated have more intellectual property to protect than non-innovators. Innovating firms therefore use any and all IPRs more frequently than those that did not. Thus for example, while 29.3% of innovators used patents, only 25.7% of all manufacturing firms did (Table1).

The use of IPRs depends on the one hand on the type of innovation and its originality and on the other hand on the characteristics of the firm and industry sector.

## The type of innovation

Patents usually protect product inventions more efficiently than process inventions. New or improved production processes are often better protected by trade secrets. Firms typically use a combination of IPRs (Chart 1).

## The originality of innovation

The value of intellectual property is to an important extent a function of its originality. By definition, patents are granted only to inventors of original, world-first inventions. Firms that introduce a world-first innovation are therefore more likely to use a patent than firms that realised a Canadian-first or those that imi-

**Chart 1. Use of IPR by type of innovation (% of firms)**

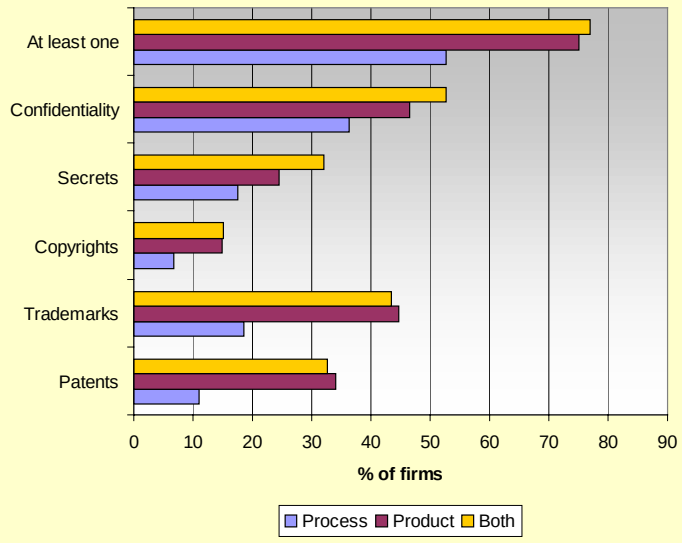



**Table 1. Use of intellectual property by innovation status**
(% of all manufacturing firms)

| Status | Share of population | Patents | Trademarks | Copyright | Trade secrets | Confidentiality | Others | Any IPR |
|---|---|---|---|---|---|---|---|---|
| Innovation | 80.7 | 29.3 | 39.8 | 13.6 | 28.4 | 48.4 | 2.7 | 72.6 |
| Unsuccessful | 7.2 | 14.1 | 25.3 | 6.4 | 14.4 | 32.6 | 1.8 | 49.7 |
| Not involved | 12.1 | 8.3 | 19.1 | 4.5 | 7.5 | 16.9 | 2.3 | 35.9 |
| All | 100.0 | 25.7 | 36.0 | 12.0 | 24.7 | 43.2 | 2.5 | 66.1 |

Source : Preliminary results of Statistics Canada Innovation Survey, 1999

Note: The statistics from the 1999 Survey presented in this and all other tables and figures are weighted by the gross business income and are representative of the population of Canadian manufacturing "provincial enterprises".

tated a new process or product already in existence elsewhere in Canada (Chart 2).

## The use of IPRs and the size of firm

The need for protection of intellectual property varies according to the size of firm for at least two reasons: one is related to the innovative activity, the other to financial constraints. Small firms are less likely to innovate than large ones. When they innovate, small firms introduce the original innovations, which contain most intellectual property worth of protecting, less frequently than larger firms do. It is therefore likely that the use of intellectual property protection (IPP) is positively related to the size of firm.

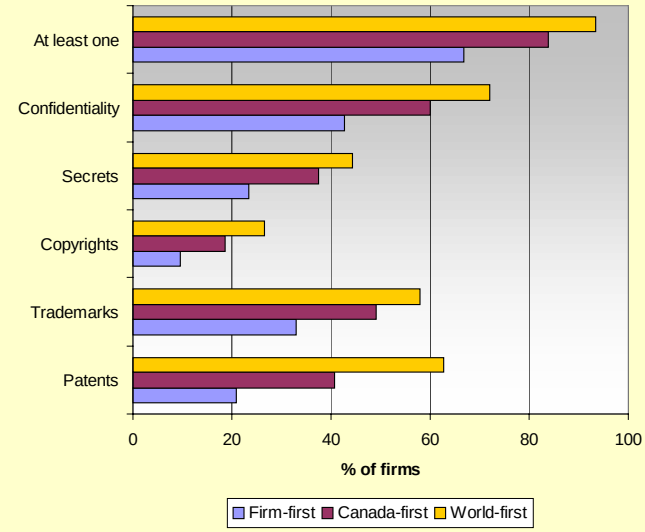
We hypothesize that IPP is biased in favour of large firms. Logically, the cost of protection—including the cost of learning and the administrative costs involved in obtaining and maintaining statutory IPRs—presents a relatively larger burden to small and medium size enterprises (SMEs) than to the large ones. SMEs also face the same cost disadvantage when it comes to enforcing their IPRs through legal action. This is confirmed by the survey results that show the use of IPRs are closely related to the size of firm; large firms use them more often than the medium and small ones.

**Table 2. Marginal effects of explanatory variables on the probability of using patents**

| Explanatory variable | Marginal effect on probability |
|---|---|
| Product innovation | 24% |
| Both product and process innovation | 18% |
| World -first innovation | 17% |
| Located in Ontario | 16% |
| Performs R&D in a separate division | 12% |
| Uses R&D subsidies | 12% |
| Canada-first innovation | 12% |
| Performs R&D | 11% |
| Belongs to core sector | 11% |
| Located in Alberta | 11% |
| Size (500+ employees) | 10% |
| Contracts out R&D | 9% |
| Uses R&D credits | 7% |
| High competition in the product market | 5% |
| Promoting firm reputation | 4% |
| Developing export market | 3% |
| Located in Quebec | 1% |
| Developing new markets | 0% |
| Size (50-99 employees) | -7% |
| Size (20-49 employees) | -8% |
| Difficulty hiring or retaining staff | -9% |
| Belongs to 'other' sector | -14% |

Note: The marginal effects are estimated by a logit regression equation evaluated at the mean values of independent variables with respect to a medium size firm employing 100-499 persons in the secondary sector, not performing R&D and having introduced an imitative firm-first innovation. Thus, for example, all things being equal, the probability that a small firm employing 20-49 persons uses patents is 8% less than the probability that a medium size firm uses patents.

**Chart 2. Use of IPRs by originality of innovation**




## The use of IPRs varies from one industry to another

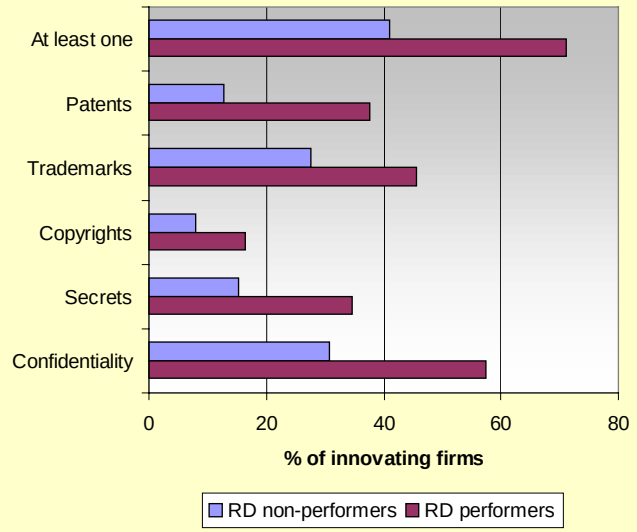
Firms operating in different manufacturing industries create different types of innovation and rely on a different mix of IPRs. These differences are related on the one hand to industry differences in technological opportunity, and on the other hand, to industry differences in the use of statutory IPRs.

The most intensive innovation and use of IPRs are found in the core sector (chemical, electronics and communication equipment, machinery and instruments industry). Core sector product innovations are used in the secondary and "other" sector and in the rest of the economy. Firms in the secondary sector (metal industries, metal products, rubber and plastics, non-metallic minerals and transport equipment) innovate and use IPRs less frequently than firms in the core sector but more often than firms in the "other" sector (food, beverage and tobacco, textiles, clothing, leather and footwear, as well as wood and paper industries belong to this sector). Significant inter-sectoral differences in the use of intellectual property rights remain even after the relationship is controlled for by the frequency of innovation.

## Research and development activity and use of IPRs

Even though R&D is not always the most important source of innovative ideas—about two thirds of firms that did not carry out R&D nevertheless innovated successfully—the majority of those innovative firms that protected their intellectual property ac-

**Chart 3. R&D and use of IPRs**




knowledged that R&D played an important role in their innovation process. Firms carrying out R&D use all IP instruments more often than firms that did not carry out R&D (Chart 3). This pattern remains true for each firm size category and each technology sector. Thus, it appears that firms that pursue active innovative strategies based on R&D have the need to protect their intellectual property and developed the competency to do so. This is particularly notable for firms that collaborate often with universities and colleges. These firms use IPRs, especially patents, more often than other firms.

## The geographical pattern of patenting

Given the high degree of economic integration between Canada and the United States, many firms patent their inventions in both countries. Some apply for patents in the US only and a small minority files patent applications in other foreign countries. Almost one out of five manufacturing firms (19%) applied for at least one patent in the 1997-1999 period. Of this number the majority (85%) applied for a patent in Canada, two thirds of firms applied for patents both in Canada and in the US, and about 20% in Canada only. Only about 10% of firms that applied for a patent did not bother to file an application in Canada and applied for patents only in the US and a small group of firms (5%) applied only in other countries than Canada or US. The pattern for the innovating firms is very similar.

## How many patent applications are filed?

There are significant inter-industry differences in the propensity to patent. The largest proportion of firms that applied for at least one patent over the 1997-1999 period is found in Agricultural, Construction and Mining Machinery industry (54.1%). This pre-eminence of patenting by the natural resource-oriented equipment producers appears to be an extension of Canada's comparative advantage in this field. In second place are firms in Communication equipment (48.2%) industry, followed by Semiconductor & Other Electronic Equipment industries (about 40%). The pharmaceutical firms, which in other countries usually lead the patenting ranking, are behind—only 30% applied for a patent. This suggests that much of pharmaceutical research in Canada does not introduce original products and processes. The lowest proportion of firms that applied for at least one patent is in clothing and wood product industries.

Most firms applied for one patent only (respectively 41.6% in Canada and 34.4% in the US). These proportions were again rather similar for innovating firms (respectively 40.3% in Canada and 32.9% in the US). The percentage of firms that applied for more than one patent declines rapidly with the number of applications. Those, mainly larger, firms that patent most frequently, apply for patents more in the US than they do in Canada. For instance, a larger proportion of firms that applied for more than ten patents did so in the US (13.4%) than in Canada (9.6%).

## The probability that a firm uses IPRs

The joint effect of economic characteristics of a firm, the type of innovation activities it pursues and the competitive strategies it adopts in the industrial and institutional environment in which it evolves are closely associated with the probability of using a particular type of intellectual property. The marginal effect of each explanatory variable on the probability that a firm uses patents is presented in Table 2. The results show that the largest core-sector firms in Ontario that performed R&D in a separate division, that did not experience difficulties in hiring and retaining qualified staff and that introduced original (world-first) product innovations were more likely to use patents than other firms.

### The use trade secrets, patents and/or trade marks increases the probability that a firm innovates

As predicted by the economic theory of innovation, those firms that protect their intellectual property with patents, trademarks and most notably with trade secrets are more likely to innovate than other firms. However, the decisions to innovate and to protect intellectual property that the innovation is expected to produce may well not be independent. When the possible interdependence of the decisions to innovate and to use patents is

taken into consideration, the positive correlation between the probability that an innovating firm uses patents remains unchanged. On the other hand, the use of patents has less effect on the firm's decision to innovate than the single equation estimates suggest. The simultaneous equation estimates also cast doubt on the significance of the contribution of government support programs to the use of IPRs and to innovation.

### Firms that use intellectual property are more profitable than the non-users

Firms use intellectual property rights presumably to derive benefits from innovation. The questionnaire contained a question asking the degree to which new products or processes contributed to the profitability of the firm. The statistical tests show that indeed the users of IPRs reported, more often than the non-users, that their innovation allowed them to maintain or to increase profitability. This positive relationship is not very strong, but it is statistically very significant. This holds true for all innovating firms but there are some sectoral differences. The positive relationship between the use of patents and the assessment of profitability exists for the core and secondary sector but not for the "other" sector. By the way of contrast, firms that found innovation profitable in the "other" sector are more frequently using trade secrets and confidentiality agreements. Trademark users report stable or increased profitability more frequently than non-users in all three sectors. Overall, the results provide statistically significant evidence that innovators who protected their intellectual property found their innovations contributing to the profitability of their firm.

## *Conclusions*

Even though IPRs are not perceived as being very effective, two-thirds of manufacturing firms used at least one instrument in the 1997-1999 period.

The probability of using IPRs varies with province and increases with:

- the size of firm
- the technology sector (from "other", to secondary, to core sector)
- the level of R&D activity
- the presence of product innovation and multiple product-process innovations
- the novelty of innovation and
- the level of government support.

Simplifying somewhat, Canadian manufacturing firms fall into two groups. The first uses patents and trademarks as a part of successful innovation strategy consisting of regular R&D financed by R&D grants and tax credits introducing world-first innovations. These are typically large firms in the technology-intensive core sector. The second group includes firms of all sizes in all sectors that rely mostly on trade secrets. They typically transfer technology from abroad by introducing Canada-first innovations and rely on government information services more than on R&D grants and tax credits.

About two-thirds of the firms that applied for a patent did so both in Canada and the US. About 20% of firms, notably those with one or few patent applications, applied in Canada only. Ten percent of firms filed for patents exclusively in the US and 5% filed exclusively elsewhere. Firms with a large patent portfolio tended to apply more frequently in the U.S.

In contrast to non-users of IPRs, those innovators who protected their intellectual property found that their innovations contributed to maintaining or to increasing profitability of their firm.

The study recommends adoption of measures to reduce the cost of obtaining, maintaining and enforcing IPRs by small and medium size firms.

*Further information: Frances Anderson, SIEID, Statistics Canada, (613) 951-6307, Frances.Anderson@statcan.ca.*

# Putting your money where your mouth is: Using knowledge management practices to design a knowledge management survey

Creating a survey on knowledge management in isolation would defeat one of the main tenets of the subject under study–working collaboratively to adapt existing knowledge to new and innovative situations. Another feature of the field of knowledge management requires developing communities of practice composed of individuals with knowledge, expertise or willingness to learn about a subject.

In the case of the Knowledge Management Practices Survey, an international pilot survey on knowledge management practices, the community of practice comprised experts from varied backgrounds working throughout the world. Creating the pilot questionnaire required cooperative work on the part of survey taking experts, knowledge management specialists and policy analysts. Bringing together a preliminary questionnaire that met the basic requirements of a group of dynamic and outspoken experts, each with individual as well as collective objectives required much compromise from all involved. Without the trust and respect that the experts held for each other and the abilities of the central coordinating team, the effort would have failed. Knowledge management, it became obvious throughout the rapid development cycle of the questionnaire, requires a great deal of concentrated effort–not a simple task.

In September 2000, a small group of like-minded individuals representing academia, private industry, statistical agencies and policy departments from a number of countries tossed around the idea of developing a survey on knowledge management. The initial intent of such a survey was to provide statistically solid information on the prevalence of knowledge management practices. Were firms and organisations really embarking upon the road to managing their intellectual and social capital? Which industries in the new economy were most likely to employ these innovative practices? While these and other questions on the economic and social impact of knowledge management were enticing for survey takers; the real questions revolved around – "How do we measure this phenomenon?" And "Is knowledge management a passing fad or does it represent a turning point in the evolution of business management?"

Academics, business experts and policy makers turned and posed their questions to a group representing national statistical agencies from Europe, Asia and North America. The statistical agencies, under the central co-ordination of the Centre for Educational Research and Innovation (CERI) of the Organisation for Economic Co-operation and Development (OECD), rose to the challenge.

An international collaborative effort began in full force in February 2001. Its efforts cumulated in three countries committing to undertake pilot surveys using a core questionnaire. While the questionnaire was developed collaboratively, Canada took the lead role in design and testing. For Canada and Denmark, the pilot Knowledge Management Practices surveys commenced in September 2001 and results are expected in March 2002. Germany's pilot will commence in the spring of 2002. The intention is for each country to produce results separately with an international comparative study to be co-ordinated by the OECD.

In Canada, the Knowledge Management Practices pilot survey was sent to firms in five industries. Firms in logging and forestry (NAICS 113) were selected to represent the primary sector. For manufacturing we targeted firms in chemical manufacturing (NAICS 325) and transportation equipment manufacturing (NAICS 336); machinery, equipment and supplies wholesalers/distributors (NAICS 417) represent trade and for the service sector, management, scientific and technical consulting services (NAICS 5416) was chosen. The sample is limited to approximately 400 firms with senior executives as the selected respondents. Questionnaire testing showed that it took less than 20 minutes to complete the questionnaire.

Data collection for the Canadian pilot Knowledge Management Practices Survey ended in late December 2001. The database and its results are scheduled for release by the end of March 2002.

The questionnaire that contains no questions requiring financial or productivity information is available on our Web site at www.statcan.ca

*Further information: Louise Earl, SIEID, Statistics Canada, (613) 951-2880, Louise.Earl@statcan.ca*

# A profile of spin-off firms in the biotechnology sector

Three out of every 10 companies in Canada's rapidly expanding biotechnology sector in 1999 were spin-off companies. These firms accounted for more than one-quarter of total revenues and 29% of total employees with biotechnology related responsibilities. This article profiles spin-off companies using data from the *1999 Biotechnology Use and Development Survey*.

**Table 1 - Biotechnology Scorecard**

| | 1997 | 1998 | 98 Spin-offs | 1999 | 99 Spin-offs |
|---|---|---|---|---|---|
| Number of Firms | 282 | .. | 123 | 358 | 123 |
| Biotech Revenues (millions of $) | $813 | $1,554 | $374 | $1,948 | $571 |
| Biotech R&D Spending (millions of $) | $494 | $695 | $176 | $827 | $244 |
| Biotech Employees | 9,019 | .. | .. | 7,748 | 2,227 |

.. Data not collected

Source: Statistics Canada Biotech Use & Development Surveys, 1997 & 1999.

## Huge revenue & employment growth for biotechnology spin-offs

In 1999[1] some 30%, or 123 of the 358 total core biotechnology firms, were spin-offs[2]. These companies showed significant growth in revenues and spending on biotech research and development from 1998 to 1999, and this growth is expected to accelerate into 2002.

As shown in Table 1, this spin-off group generated revenues of $571 million dollars in 1999. This is up 52% over the previous year, more than double the growth rate in revenues for the biotechnology sector as a whole. In addition, the spin-offs employed 4,079 people, 6.5% of total employment in the sector. When compared to the employment results for the rest of the core group of biotech firms, spin-off firms have a much higher concentration of biotech employees as the spin-off firms employed 29% of the biotech employees.

## Research & development options

Once research and development has created some form of exploitable intellectual property (IP), there are at least two options available each with its own benefits and drawbacks. One option is to license the IP to an existing firm to exploit and return royalties to the originating entity. This typically has a low risk factor but significantly reduced rewards for the originating entity. A second option is for the originating entity to create or spin-off a new company, a firm that will do the necessary work to exploit or optimize the discovery. This option has a greater reward potential, but also comes with greater risks with the possibility that the firm will fail and the commercialization potential will be missed.

## Universities and research hospitals dominate

Given the intense academic nature of biotechnology developments, not surprisingly, the vast majority of the spin-offs, 91% or 112 were formed by universities or research hospitals. Seventy-five of these firms were concentrated in the area of human health.

Universities are in the business of producing knowledge and are not always equipped to take new discoveries through to the production phase. However, universities may use spin-offs as a vehicle not just to commercialize a development, but to give them greater access to investment for research and development.

## Patent impact

Spin-offs had fewer existing patents (1,029) than non-spin-off firms (2,673) did in 1999. However, the spin-off firms held 2,229 pending patents, 9% more than the 2,029 held by non-spin-off firms. Spin-offs also had a strong product development pipeline[3] with more than 6,500 products at various stages of development. This compares to over 11,000 for the non-spin-off firms.

## Conclusion

Canada's growing biotechnology sector is producing a significant number of spin-off companies. Universities or research hospitals created the vast majority of the spin-off firms. These firms are experiencing growing revenues, providing significant employment opportunities and are investing and spending more on biotechnology research and development. This growth is expected to continue to accelerate into the year 2002.

*For further information, contact Craig Byrd, SIEID, Statistics Canada, (613) 951-1827, craig.byrd@statcan.ca).*

[1] The 1999 Biotechnology Use and Development Survey was conducted as part of a project to develop biotechnology statistics and was funded under the Canadian Biotechnology Strategy. The survey was administered to a sample of 3,377 firms in selected North American Industry Classification System industries in Canada's industrial sector identified as having the potential to use biotechnologies. The response rate was 66%. Results were weighted to reflect the entire population of firms in the selected industry sectors.

[2] The 1999 Biotechnology Use and Development Survey defined spin-offs as "…a new firm created to commercialize inventions and technology developed in universities, firms or laboratories."

[3] The product development pipeline is the process of moving a product through the various stages of development, from R&D to the market.

# Time to skill

S&T skills are a high priority for the future. Innovation will be key to maintaining Canada's competitive advantage in the New Economy. People with S&T skills conduct the research and develop the new products that fuel innovation. Where do S&T skills come from and how does Canada compare with other countries? A new Statistics Canada study delves into the ins and outs of the "science stream", starting from Grade 4 though to the workforce.

## The thrill of discovery

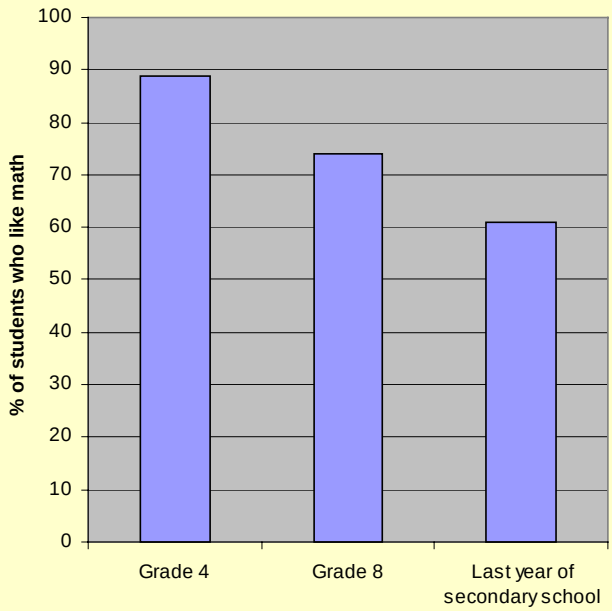
It seems as though every Grade 4 class in Canada has boundless enthusiasm for mathematics and science. Science reveals the mysteries of how things work and mathematics wields power over large numbers and abstract thinking. In fact, the Third International Mathematics and Science Study (TIMSS), conducted in 1995, shows that 89% of Grade 4 students liked math and 80% liked science.

> By the last year of high school, only 42% of the students were enrolled in both math and science courses. Students not enrolled in science were much more likely to be to study business. They were less likely to be contemplating studies in engineering or health sciences.

For Grade 8 students, 74% liked math and 68% were keen on science. This drop continued into the last year of high school, wherein only 61% of the students liked math (See Figure 1) and the popularity of the sciences varied from biology at 60% to physics at 31%. By the last year of high school, only 42% of the students were enrolled in both mathematics and science courses.

Michael Bordt, SIEID's Chief of Human Resources and Intellectual Property, recently accompanied Mrs Brede's Grade 4 class of Ottawa's Meadowlands Public School on a field trip to Canada's Museum of Science and Technology. "We learned all about sound and participated in many experiments," says Michael. "It's amazing to see the thrill of discovery at this age. Yet, when you look at the studies, you know that there's a possibility that many will find science difficult or boring by the end of high school."

**Figure 1. Student opinion of mathematics, 1995**




Source: IEA, 1998; Statistics Canada 1999b.

## Choices in secondary school

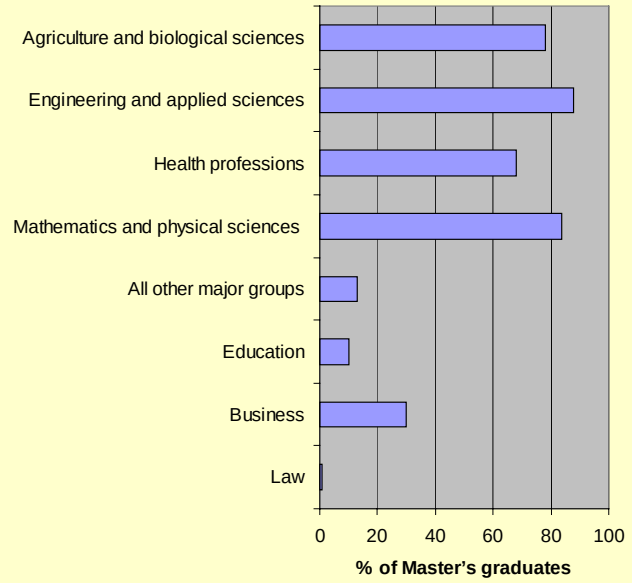
Canadian students consistently rank among the highest in the world in terms of math and science performance. The most recent study (OECD's PISA) places Canada's 15-year olds among the top five countries in the world in reading, mathematics and science. Despite this capability, the potential is perhaps not being fully realized. High school students in the earlier TIMSS cited difficulty with the subjects and a lack of interest as the main reasons for their reluctance to pursue them when given the choice.

Whether or not they were enrolled in math or science courses, most Canadian students in their final year of secondary school in 1995 planned to go on to college or university. Their selection of postsecondary program appears to have been influenced by their choices in math and science in high school. Students not taking math were much less likely to be planning postsecondary education in business, engineering or health sciences than their counterparts. Those students not enrolled in science courses were much more likely to be planning studies in business than those still taking science courses were. However, they were less likely to be contemplating studies in engineering or health sciences than their counterparts.

## The science stream

This early targeting of careers may be a reason for the stability in the "science stream" between university degrees. Very few of the 1995 graduates changed between science programs and non-science programs between bachelor's, master's and doctorate studies. However, a large proportion of master's graduates in business had previous degrees in science.

**Figure 2. Master's graduates with a previous degree in science, 1995**




Source: Statistics Canada, National Graduates Survey 1995. Special tabulations.

"There are some interesting relationships between field of study and occupation that we haven't had a chance to fully analyse," said Cathy Read of SIEID, one of the contributing authors. "Dentistry graduates almost always become dentists but very few geology graduates end up becoming geologists. Furthermore, fewer than half of the graduates working as computer programmers actually had a degree in computer science. It would take a lot more work and new surveys to say much more about the other skills that students are acquiring in postsecondary institutions."

According to Cathy, "Other researchers tend to focus on one stage of the evolution of S&T skills. This is one of the few studies that try to make sense of the entire education and early workforce experience of Canada's students. This work points out the need for studies that track students' attitudes and performance over long periods of time."

Data from the TIMMS-R (for repeat) conducted in 1999 were not available in time to be included in this study. However, Robitaille and Taylor (2001) have found that in 1999, math and science performance for Grade 8 was higher than 1995 by two scale points. Furthermore, they conclude that, in 1999, the Canadian students felt more positively towards these subjects than their counterparts in other countries. Whether they felt more positively than they did in 1995 is a matter of further analysis.

*This article is derived from a set of articles on the "Determinants of Science and Technology Skills" published in Statistics Canada's "Education Quarterly Review", Winter 2001 Issue (Cat. No. 81-003-XIE). A summary of the findings was published in the Statistics Canada Daily on December 19, 2001. Results are based on the Third Annual Mathematics and Science Study (TIMSS) conducted by the International Association for the Evaluation of Educational Achievement as well as Statistics Canada's National Graduates Survey.*

*Statistics Canada participated in the OECD's Programme for International Student Assessment (PISA), the results of which were released in the Statistics Canada Daily on December 4, 2001 and published in* ***Measuring up: The performance of Canada's youth in reading, mathematics and science*** *(81-590-XIE, free).*

*Robitaille, Dr. David F. and Dr. Alan R. Taylor, 2001,* ***Third international mathematics and science study: Canada report****, Education Quarterly Review, 2001 Vol. 7, No. 4, Cat. No. 81-003-XIE, Statistics Canada.*

*For further information contact: Michael Bordt, SIEID, Statistics Canada, (613) 951-8585, Michael.Bordt@statcan.ca.*

# Comparison of Canadian and European surveys of innovation

In recent years, comparing national innovative performances has become increasingly important as countries recognize the importance of innovation for economic growth. Over the past decade, various member countries of the Organization for Economic Co-operation and Development (OECD) have carried out surveys of innovation, using a standard framework proposed in the Oslo Manual. The present survey compares data from the Canada's most recent Survey of Innovation (1999) with data from the second European Community Innovation Survey (CIS 2) (1994-1997). Canada is compared with four European countries: France, Germany, Ireland and Spain.

## *Background of the survey*

Although international comparability was central to the design of both surveys, some discordance was inevitable, and some exploratory work was necessary before Canada could be compared with the European countries. This report, for example, will study the comparability of Canada's 1999 Survey on Innovation with the CIS 2 and then, using data that have been made comparable, will compare national innovation performances.

## *Comparison of the two surveys*

Although the two surveys are quite similar, there are differences between them. This report will study some of the major differences and the changes needed to harmonize the data.

### Reference periods

A first major difference had to do with reference periods. Respondents were asked, "Have you innovated during a typical three-year period?" In Canada, this period was from 1997 to 1999; in Europe, it was from 1994 to 1996.

What is the effect of these differing reference periods? The fact that the surveys do not cover the same reference periods is probably not very important, at least for highly innovative firms that are likely to innovate on an ongoing basis. For example, for highly innovative firms, we can expect incentives to innovate to be the same over any three-year reference period, whether from 1997 to 1999 or from 1994 to 1996. Analysis of low-technology firms such as those in the lumber industry is somewhat more complicated. Although these less innovative firms might not innovate every year, they are likely to have adopted new technology over a three-year period, particularly given the significant changes in technology between 1994 and 1999.

The widespread use of Information and Communication Technologies (ITCs) in recent years, and their effects on the process of innovation, may have enhanced Canada's innovation performance in comparison with that of the European countries, particularly in low-technology industries. For example, we might expect Canadian firms to have benefited more from the broader distribution of ITCs. As well, the cost of telecommunications has long been lower in North America than in Europe; this factor, too, would have fostered broader distribution of ITCs in Canada than in Europe. Comparatively speaking, then, Canadian firms may have had an advantage in adopting ITCs.

### Legal status of the survey

A second factor affecting analysis of the results is the legal status of the survey. Responding to the questionnaire was mandatory in Canada, France and Spain, but voluntary in Germany and Ireland.

The effect of the legal status of a survey on highly innovative firms is likely insignificant. On reading the questionnaire, an innovative firm would rightly have the impression that it could provide relevant data, and would thus tend to respond to the questionnaire. However, less innovative firms, not having innovated, would not have the impression that they could make a significant contribution to the survey, and would thus have little motivation to respond to the questionnaire. If responding to the questionnaire is voluntary, then, we can expect a higher percentage of innovators and a smaller pool of non-innovators.

**Table 1. Percentage of innovators, by country (using the definition contained in the Oslo Manual)**

| | Canada | France | Germany | Ireland | Spain |
|---|---|---|---|---|---|
| *Technology level* | | | | | |
| Low | 77% | 38% | 60% | 64% | 20% |
| Medium | 81% | 44% | 71% | 78% | 32% |
| High | 88% | 62% | 74% | 82% | 55% |
| *Firm size* | | | | | |
| Small | 75% | 35% | 63% | 69% | 22% |
| Medium | 81% | 50% | 69% | 78% | 44% |
| Large | 88% | 77% | 86% | 85% | 77% |
| **TOTAL** | **80%** | **44%** | **68%** | **74%** | **30%** |

Source: Mohnen and Therrien (2001), using data from:

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

### Statistical unit

Another major difference is the statistical unit. In Canada, the concept of "provincial enterprise" was defined and used, while in Europe, the usual definition of "enterprise" was the statistical unit. What is a "provincial enterprise"? It is a group of all establishments of a given firm in the same industry within a province. When this concept is used, the sample may repeatedly count a given firm (especially if it is large), thus over-representing the behaviour of large firms (for example, massive investment in R&D).

Using as a sample the firms that responded to the questionnaire only once, we can test the homogeneity of responses across statistical units. These tests indicate no change in the percentage of innovative firms (or in other variables of interest), regardless of whether the full sample or a sub-sample of firms operating in a given province or industry is used. In this regard, changing the statistical unit does not alter the results.

Other adjustments to the samples were necessary before the data could be compared. The Canadian and the European industrial classifications are not the same. Although in Canada the new North American classification was used to facilitate international comparisons (particularly among countries in North America but also with countries in Europe), despite all efforts some adjustments were necessary. Concerning the target population, the samples from both surveys exclude smaller firms, which means that the surveys provide information mostly on medium-sized and large firms, both in Canada and in Europe.

## Results

The questionnaires asked firms, "During the three years of the reference period, did you introduce a new or improved product or process to your firm?" This definition implies that the product need not be new on the market, but need only be new to the firm. It also measures firms' capacity for adopting new technology and for creating technology. This point explains the very high percentage of innovators (80% in Canada). The percentage of innovative firms is higher in Canada than in the European countries (see Table 1). This percentage is close to the Canadian level in Ireland and Germany, and somewhat lower in France and Spain. Bearing in mind that responding to the questionnaire can be mandatory or voluntary, we note that the percentage of innovators is higher in Ireland and Germany than in France and Spain.

Not surprisingly, in each country firms in high-technology industries are most often innovative. The percentage of innovative firms is considerably higher than average in high-technology industries. Interestingly, more than three-quarters of Canadian low-technology firms had innovated (or at least adopted new technology).

As well, the percentage of innovative firms in low-technology industries is much higher in Canada than in the other countries. This point supports the theory that Canada's performance rated higher because the reference period for the Canadian survey was more recent (1997-1999, not 1994-1996).

Innovation can also be defined as the percentage of sales from innovative products. On average, new, improved or innovative products allowed Canadian firms to increase their sales by 27% (see Table 2). While Canada leads in terms of the percentage of innovators, it lags in terms of the percentage of sales from innovative products as a measure of innovation. There is a big difference between introducing a product onto the market and successfully profiting from the innovation.

Thus far, we have used a broad definition of innovators: firms that have introduced products that are new or improved, either to the firm or on the market. It would be interesting to highlight the actual inventors, whom we refer to as first-time innovators. Where novelty of innovation is concerned, the European questionnaire distinguishes between products that are new to the firm and products that are new on the market. In Canada, an innova-

**Table 2. Percentage of sales from new or improved products**

| | Canada | France | Germany | Ireland | Spain |
|---|---|---|---|---|---|
| *Technology level* | | | | | |
| Low | 22% | 15% | 33% | 17% | 39% |
| Medium | 25% | 27% | 49% | 32% | 53% |
| High | 40% | 35% | 55% | 57% | 46% |
| *Firm size* | | | | | |
| Small | 26% | 20% | 50% | 25% | 38% |
| Medium | 28% | 25% | 42% | 35% | 41% |
| Large | 27% | 28% | 49% | 42% | 51% |
| **TOTAL** | **27%** | **27%** | **48%** | **35%** | **48%** |

Source: Mohnen and Therrien (2001), using data from: Canada: 1999 Survey on Innovation, Statistics Canada; EU: CIS 2, OSCE.

**Table 3. Percentage of first-time innovators, by country**

| | Canada | France | Germany | Ireland | Spain |
|---|---|---|---|---|---|
| *Technology level* | | | | | |
| Low | 20% | 14% | 20% | 22% | 6% |
| Medium | 28% | 23% | 26% | 26% | 12% |
| High | 38% | 32% | 30% | 38% | 25% |
| *Firm size* | | | | | |
| Small | 17% | 15% | 20% | 23% | 7% |
| Medium | 27% | 23% | 24% | 28% | 18% |
| Large | 40% | 44% | 47% | 52% | 40% |
| **TOTAL** | **26%** | **21%** | **25%** | **27%** | **11%** |

Source: Mohnen and Therrien (2001), using data from

Canada: 1999 Survey of Innovation, Statistics Canada; European Union (EU): CIS 2, OSCE.

**Table 4. Percentage of sales from new or improved products (first-time innovators only)**

| | Canada | France | Germany | Ireland | Spain |
|---|---|---|---|---|---|
| *Technology level* | | | | | |
| Low | 24% | 20% | 42% | 19% | 39% |
| Medium | 31% | 29% | 53% | 38% | 51% |
| High | 53% | 40% | 59% | 69% | 46% |
| *Firm size* | | | | | |
| Small | 29% | 29% | 58% | 30% | 52% |
| Medium | 30% | 31% | 52% | 46% | 47% |
| Large | 36% | 31% | 54% | 47% | 47% |
| **TOTAL** | **35%** | **31%** | **54%** | **43%** | **47%** |

Source: Mohnen and Therrien (2001), using data from:

Canada : 1999 Survey on Innovation, Statistics Canada; EU: CIS 2, OSCE.

tion can be new to the firm, new in Canada, or new worldwide. In order to compare Canadian and European data, we combined innovations that were new worldwide and those that were new in Canada, as the closest equivalent of the ”new on the market” concept used in the European surveys. If this limited definition of innovation is used, the differences between countries are lessened, both in terms of percentages of innovators and in terms of percentages of sales from innovative products (see Tables 3 and 4).

In conclusion, comparing the innovation performances of Canada and the European countries calls for a minimum of adjustments. Interesting comparisons can be drawn despite differences in the questionnaires and organization of the surveys. These initial descriptive data already highlight the effects of firm size, industry characteristics and, perhaps, response rates and reference periods. In order better to understand differing national performances, it would be necessary and interesting to study the available data in greater depth (in a future survey) using econometric techniques.

***References:***

This article is based on the paper entitled *How Innovative are Canadian Firms Compared to Some European Firms? A Comparative Look at Innovation Surveys*, by Pierre Therrien and Pierre Mohnen, soon to be published in the journal ***Technovation***.

*For further information: Frances Anderson, SIEID, Statistics Canada, (613) 951-6307, Frances.Anderson@statcan.ca.*

# Use of biotechnology in Canadian industry

Firms using biotechnologies in their day-to-day operations have adopted biotechnologies into their operations in an effort to make efficient use of resources. An important segment of firms using biotechnology is the adoption of biotechnology, the integration from the realm of R&D to commercial use in products and processes. This article explores some of the characteristics of biotech users that employ biotechnologies, addressing the key questions - "Why use biotechnology?" and "Why not use biotechnology?"

The use of biotechnology[4] in human activity is not new. Classical forms of biotechnologies such as fermentation have been a part of industrial processes for decades, if not centuries. But today, more recent developments in biotechnologies are diffusing throughout the economy. Industrial, health and environmental activities are being transformed. Traditional biological processes continue today but are enhanced by scientific processes intended to not only understand organisms but to decode and modify organisms and at times contribute to new products or processes.

Discussions on biotechnology often focuses on this new, cutting edge science and those firms conducting research and development programs on these new biotechnology products and processes. However an important segment of the biotechnology sector is the adoption of biotechnology, the integration from the realm of R&D to commercial use in products and processes. Firms using biotechnologies in their day to day operations have adopted biotechnologies into their operations in an effort to make efficient use of resources. This article explores some of the characteristics of the firms that use biotechnologies.

## Biotechnology Use

Almost 800 unique firms use biotechnologies combined for 1,492 instances of use for a variety of purposes. The primary purpose for using biotechnologies was for production with 824 incidences of use, followed by R&D purposes[5] with 606 and environmental purposes with 301. Some firms reported more than one biotechnology used and reported some biotechnologies used for more than one purpose.

As previously noted, biotechnology has been used in areas such as food production for centuries (brewing, fermentation), but biotechnologies based in part on new discoveries in the late 1970's are found in the industrial sector. Many of the biotechnologies have been in use for a decade or more for example bioprocessing based biotechnologies. A total of 171 firms used microbiology/virology/microbial/ecology sub-group for R&D, production and environmental purposes, averaging almost 11 years in use, one of the longest average periods a biotechnology was used.

Over the subsequent three years, only 2% of firms intended to adopt the use of biotechnologies, suggesting a saturation of biotechnologies at current technical levels. Many of the biotechnologies used had been in use for a decade or more and the bioprocessing based biotechnologies had the least planned adoption and the greatest average number of years in use.

Combining the core group and the users group creates a more complete picture of biotechnology use. There were a total of 1,142 firms using biotechnologies that together used 3,241 biotechnologies. The 358 core firms had a total of 423 instances of using DNA based biotechnologies, with research and development (R&D) emerging as the primary use, reported in 416 instances. This far outstripped their use in current production. DNA based biotechnologies is the youngest of the techniques. It includes bioinformatics used for an average of 3 years by 83

[4] Biotechnology is not an industry, but rather a collection of techniques and this is reflected in the methodology of the survey. The questionnaire was sent to 2,999 firms from industries found within the NAICS codes where the possibility of biotechnology use was identified. A second sample group of firms thought to be developers of biotechnology, supplemented the industry based NAICS sample. Respondents were divided into three groups depending on their reported level of involvement in biotechnology. The core group, for whom biotechnology is central to the firm's activity, the users group that use biotechnology in their day to day operations, and finally, the non-users of biotechnology.

[5] A possible distinction arising from core firms' R&D activities and the users group conducting R&D using biotechnology can be explained. The users group employs biotechnology in R&D activities as one method or step to achieve a goal or end result (product or process) that is not necessarily related to biotechnology or where the end product is not a new biotechnology product or process. The core group may use biotechnology in the same way, but also to create new biotechnology based products or processes and also consider biotechnology R&D central to their activities.

firms and used almost entirely for R&D purposes, the lowest average time of use of any biotechnology.

## Why use biotechnology?

Firms rated the improvement in product quality as the number one benefit derived from using biotechnologies. It was the second highest benefit in the 1996 survey. Of note, lower cost factors were given little importance as benefits from using biotechnologies. This stands in contrast to the results of the 1996 survey where lower production costs rated as the greatest positive influence in introducing biotechnologies to a firm. A benefit of increased production flexibility was rated highly by firms, as was increased sales.

## Why not use biotechnology?

It is important to understand the characteristics of firms using or developing biotechnologies. However, information about firms not using biotechnology and their reasons contributes to a greater understanding of the uses of biotechnology.

Industries in about 92% of the selected NAICS codes do not use biotechnology. In comparison, using different methodology but a similar universe the *Biotechnology Use by Canadian Industry Survey* found that about 14% of the sample used at least one biotechnology in the 1996 fiscal year. Of the 8,455 non-users, only 184 firms planned to introduce biotechnologies within three years. Of these firms, 100 cited introduction of environmental biotechnologies in future plans followed by biochemistry/immunochemistry and then DNA based biotechnologies. Collectively these represent an adoption rate of 2% over a three-year period in industries known to use biotechnologies.

The main barriers to using biotechnology were attributed to cost factors by 50% of firms, followed by lack of qualified staff by 41% of firms and then public acceptance cited by 36% of firms. The 1996 survey found that the primary impediments to using biotechnology among non-users were lack of financial justification, lack of information, biotechnologies not sufficiently developed, insufficient market for products and lack of scientific and technical information.

## Summary

Biotechnology activity is found throughout Canadian industry. Some of its benefits include the creation of new goods and services, changes to production processes and patterns of consumption, and improvements to the standard of living. In the long term, biotechnology may play a role in improving performance and productivity in several Canadian industries.

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*Further information: Chuck McNiven, SIED, Statistics Canada, (613) 951-1233, Chuck.McNiven@statcan.ca.*

# Cognitive testing in questionnaire development, Part one: The importance of the appropriate respondent

Survey design and development has many stages, all of which present the researcher many new and often surprising results. During the conceptualisation of the recently piloted **Knowledge Management Practices Survey**, analysts at Statistics Canada undertook a series of cognitive tests with potential respondents. These tests served many purposes with the primary objective being to obtain information about how well respondents understood the questions on draft questionnaires. At Statistics Canada, we use cognitive interviews to test questionnaires and other survey instruments as part of our standard operating procedures. Over the years, our Questionnaire Design Resource Centre (QDRC) has developed advanced techniques and experienced analysts to conduct these interviews.

This column presents some of the results of tests administered during the development of the questionnaire for the Knowledge Management Practices Survey. Paul Kelly and Marcel Levesque of QDRC conducted the tests with Louise Earl and Michael Bordt of SIEID acting as the subject-matter experts. The interviews were conducted in Ottawa, Toronto and Montreal in May and June of 2001. All four analysts assisted at interviews in Ottawa, with Paul and Louise conducting the interviews in Toronto and Marcel and Louise those in Montreal. All of the interviews in Montreal were conducted in French. The tests in Ottawa and Toronto were in English. One respondent in Ottawa responded to the questionnaire in English but discussed the concepts in French.

## *The importance of the appropriate respondent!*

An important part of the cognitive test for the Knowledge Management Practices Survey (KMPS) was determining to whom in a firm or enterprise to address the survey. Due to the nature of the survey–questions on management techniques and strategies– we believed that the respondent should be the firm's most senior executive, his or her designate or chief knowledge officer. Cognitive testing of the questionnaire let us validate this hypothesis.

Talking to the appropriate respondent really made a difference! In one interview with a Chief Financial Officer, he mentioned throughout the test that he really was not the appropriate person to answer the questions. However, at the end of the test when we inquired directly if he should be sent the questionnaire he answered unwavering "Yes". When we probed, the reason put simply is that answering Statistics Canada's questionnaire was one of his responsibilities. All of Statistics Canada's questionnaires that went to his company passed by his desk before they were returned.

In another interview, we met with a senior informatics officer. She also commented that she should not answer the questionnaire, but found the topic intriguing. She mentioned that since we were collecting the questionnaire and that her answers would not be seen by anyone else in her company, she would answer them frankly. When questioned about whether her answers would have differed if the questionnaire were to be seen by others in her company, she replied in the affirmative. Her comments reflected mostly on the questions on the effectiveness of the knowledge management practices in place. Due to funding and other internal organisational considerations, she indicated that her responses about the effectiveness of knowledge management practices would have been more positive if the questionnaire had been passed up through senior management. The responses, therefore, would have reflected what she thought senior management wanted rather than reality.

In another interview, the general manager quite happily completed the questionnaire and interview. At the end of the interview, he mentioned that normally he would have just passed it off to his administrative assistant to run through the company. He would then review the questionnaire prior to having it returned to Statistics Canada. Another general manager commented that his opinions, especially about the effectiveness of his management practices would not reflect those of his staff. Finally, another respondent from human resources commented that completing the questionnaire and the interview helped her to better understand a recent speech made by her vice-president!

Most of the interviews were conducted with a sole representative from the company. However, we did have a few interviews with more than one representative. In these instances, the organisational hierarchy became quickly apparent: subordinates rarely ventured an opinion unless directly asked by their superiors and then, they generally hedged their answers.

One very dynamic interview occurred with two vice-presidents. These two gentlemen treated each other with obvious respect and with no fear of reprisals if they were not in agreement. In fact, they quite openly debated the organisation's responses to some of the questions, each learning from the other and us from them. Their debates helped clarify how the questions were understood, making the interview a win-win situation for all involved.

Sending the questionnaire to the appropriate respondent within an organization is very important to the success of the survey. However, survey researchers need to keep in mind, as well, who is answering the questions.

*Further information: Louise Earl, SIEID, Statistics Canada, (613) 951-2880, Louise.Earl@statcan.ca.*

# The importance of competition for innovation

Innovation is the key driver of productivity growth. Firms have to be highly innovative to gain competitive advantage in today's increasingly competitive global market. The competition-innovation linkage is empirically examined recently, using Statistics Canada's **Survey of Innovation 1999**. The empirical evidence shows that competition has a positive and significant impact on both technology invention and technology adoption, providing strong support for a competition policy that is geared to encourage innovation.

*Note: The author, Jianmin Tang, is a senior research economist with Industry Canada's Micro-economic Policy Analysis Branch. The research was conducted in cooperation with SIEID as part of it's Facilitated Access Program.*

## Introduction

Innovation is a continuous process of discovery, learning and application of new technologies and techniques from many sources. It is the fundamental driver of productivity growth and improvements in living standards. Innovation has become an important focus of virtually every country's policy agenda. Indeed, the 2001 Speech from the Throne stated the fundamental importance of innovation. It set out an ambitious innovation agenda for Canada covering the next 10 years: *"Our objective should be no less than to be recognized as one of the most innovative countries in the world. …. We must strive for Canada to become one of the top five countries for research and development performance by 2010."* To promote innovation and to realize the innovation target, we first have to understand the underlying factors that motivate firms to undertake innovation activities.

Many policy makers and researchers believe that competition increases the pressure for firms to innovate. The belief is mainly based on two observations. First, firms in the same market can gauge their relative performances. The cross-comparison increases the pressure for firms to perform better than their counterparts, which leads to more innovation effort. Second, competition raises the demand elasticity for products of each competing firm. The increased elasticity will generate more gains for a firm if it succeeds in achieving better performance than its counterparts, creating incentives for the firm to innovate.

The importance of competition for innovation in the manufacturing sector is empirically examined in my recent study "Competition and Innovation Activities: Micro Evidence", using Statistics Canada's Survey of Innovation 1999. The survey concerns firms' innovation activities and environment for the 1997-99 period. The purpose of this short note is to provide a summary of that study.

## Innovation activities and competition

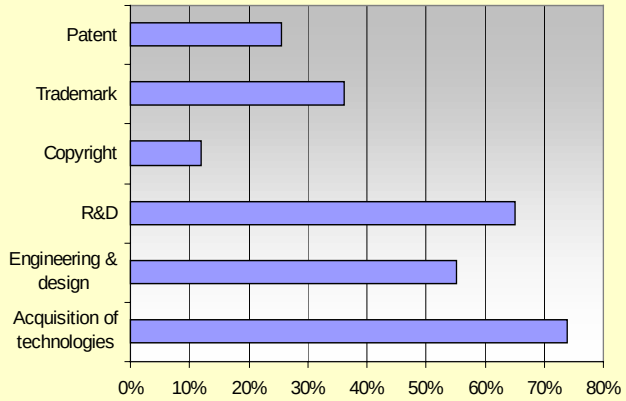
In that study, I consider two innovation activities: technology invention, which is often called fundamental innovation, and technology adoption, which is often called applied innovation. I measure technology invention, technology adoption, and competition as a weighted sum of multiple indicators, with the weights determined by a latent variable model. There are four advantages in following this approach. First, it captures multiple dimensions of innovation activities or competition since different indicators measure innovation activities or competition from different perspectives. Second, it recognizes that each indicator is imperfect. For instance, patents are an imperfect indicator of technology invention since not all invention is patented and some firms prefer using trademarks to protect their intellectual properties. Third, it avoids the multi-colinearity problems in a regression analysis since some indicators such as R&D and patents are highly correlated with one another. Finally, it reduces the number of variables and helps to summarize the data.

*Technology invention* is measured as a weighted sum of five qualitative indicators: patents, trademarks, copyrights, R&D, and engineering & design. Similarly, *technology adoption* is measured as a weighted sum of three indicators: R&D, engineering & design, and acquisition of technologies. R&D and engineering & design are indicators for both technology invention and technology adoption since they both are inputs for technology invention and technology adoption, although the degree of importance may be different. All of these innovation indicators are binary variables. For instance, if a firm performed R&D in the 1997-99 period, the R&D indicator for the firm equals one; otherwise, it equals zero.

In terms of the percentage of firms using patents, trademarks or copyrights to protect their intellectual properties, the most popular method for all manufacturing firms as a whole was trademarks (36%), followed by patents (25%), as shown in Figure 1. As for other innovation indicators, the most common innovation activity in the manufacturing sector was acquisition of technologies (undertaken by 74% of firms), followed by R&D (performed by 65% of firms).

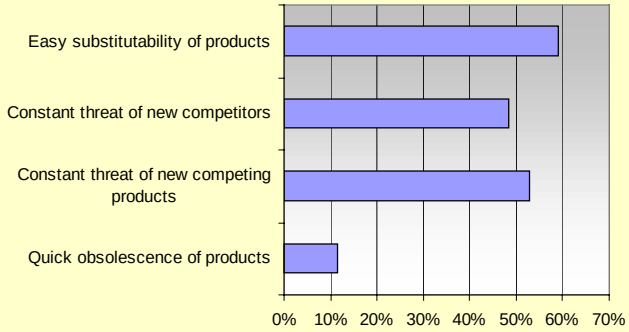
Unlike most previous studies, which often use market share or concentration to measure competition, I measure competition as

**Figure 1. Percentage of manufacturing firms engaging in innovation activities**




Source: Tang, Jianmin, 2001, *Competition and Innovation Activities: Micro Evidence*, Mimeo, Industry Canada.

**Figure 2. Percentage of manufacturing firms that highly agreed* with statements regarding their competitive environment**




* A statement is highly agreed by a firm if the firm scores 4 or 5 on the statement.

Source: Tang, Jianmin, 2001, *Competition and Innovation Actiactivities: micro evidence*. mimeo. Industrv Canada.

a weighted sum of four qualitative indicators: "my clients can easily substitute my products for the products of my competitors", "the arrival of new competitors is a constant threat", "the arrival of competing products is a constant threat", and "my products quickly become obsolete". In the survey, firms were asked to evaluate their competitive environment by indicating their perception of each of the statements by using the scale from 0 to 5, where 0 for irrelevant, 1 for strongly disagree and 5 for strongly agree.

The strongest survey response, in terms of the percentage of firms that highly agree (score 4 or 5) with a statement, was for the statement: "My clients can easily substitute my products for the products of my competitors" (59%), followed by the statement: "The arrival of competing products is a constant threat" (53%).

## Empirical analysis

The importance of competition for innovation is estimated by regression analyses. In the regression equations, technology invention or technology adoption is modeled as a dependent variable. Competition is an independent variable. The control variables include competition for qualified workers, market transparency, government innovation support programs, firm size dummies, and industry dummies. All of the control variables are also based on the survey.

After controlling for other factors, the estimation results show that competition has a positive and significant impact on both technology invention and technology adoption. And, this is true for each of the six innovation indicators. Thus, the empirical evidence substantiates the belief that competition induces innovation.

This finding strongly supports a competition policy that is geared to encourage innovation. By extension, this finding also indicates that Canada needs to rethink its regulations in areas such as foreign ownership restrictions that prevent entry and reduce the benefits of competition.

## References

Tang, Jianmin, 2001, *Competition and Innovation Activities: Micro Evidence*, Mimeo, Industry Canada.

*Further information: Jianmin Tang, Senior Research Economist, Micro-Economic Policy Analysis Branch, Industry Canada, (613) 946-1621, tang.jianmin@ic.gc.ca.*

# What's new?

Recent and upcoming events in connectedness and innovation analysis.

## Connectedness

In the fall, the fifth issue of the Connectedness Series was released. The report, entitled *Electronic Commerce and Technology Use* (56F0004MPE), presents the newest findings on e-commerce. It reveals that in 2000, the value of orders received over the Internet with or without online payments expanded by 73% to $7.2 billion doubling in importance from 0.2% to 0.4% of total operating revenues compared to 1999, while at the same time the proportion of businesses selling over the Internet declined, becoming concentrated into fewer and larger businesses accounting for 6% of all businesses. Business-to-business sales were higher than business-to-consumer by a factor of four-to-one, and a sizeable proportion of online sales was exported. The report also analyzes the use of various ICTs by the public and private sectors, uncovering industrial differences.

In December, the latest statistical profile of the ICT sector was released. The report, entitled *Information and Communications Technologies in Canada* (56-506-XIE), provides in-depth analysis of the state and growth of the sector for a variety of variables, including GDP, employment, R&D and international trade. It reveals that in 2000, the sector accounted for 7.3% of business-sector GDP, while experiencing a rate of growth substantially higher than the whole economy.

*Coordinator: George Sciadas (613) 951-6389*
*George.Sciadas@statcan.ca*

## Telecommunications

### Annual survey of telecommunications service providers

Collection of data for the annual survey for year 2000 is complete. Preliminary data expected available in May.

### Quarterly survey of telecommunications service providers

Status: Third quarter survey results for 2001 released in December 2001. Fourth quarter 2001 data to be released in April 2002

*Contact: Haig McCarrell (613) 951-5948*
*Haig.McCarrell@statcan.ca*

## Broadcasting

*Contact: Daniel April (613) 951-3177*
*Daniel.April@statcan.ca*

## Household Internet use

Status: Data collection activity for the 2001 Household Internet Use Survey will commence January 20th to February 2, 2002.

*Contact: Jonathan Ellison (613) 951-5882*
*Jonathan.Ellison@statcan.ca*

## Business e-commerce

### *Survey of electronic commerce and technology*

Status: A working paper *Innovation and change in the public sector: a seeming oxymoron* by Louise Earl was released on January 31. This paper is based on information from the 2000 Survey of Electronic Commerce and Technology (SECT) and concentrates on the introduction of organisational and technological change in the public sector.

*Contact: Greg Peterson (613) 951-3592*
*Greg.Peterson@statcan.ca*

## Science and innovation

## S&T activities

### Research and development in Canada

Status: Statistics on Total Spending on R&D in Canada were released in October 2001 in Science statistics Vol. 25, No. 8 (Cat. No. 88-001-XIB).

### Federal and provincial S&T

Federal science expenditures

Status: *Federal Government Expenditures on Scientific Activities, 2001-2002* was released in November 2001, in Science Statistics, Vol. 25, No. 9 (Cat. 88-001-XIB). Status: Scientific and Technological (S&T) *Activities of Provincial Governments, 1992-93 to 2000-01* was released in December 2001 in Science Statistics, Vol. 25, No. 11 (Cat. 88-001-XIB). *Distribution of Federal Expenditures on Science and Technology, by Province and Territories, 1999-00* was released in December 2001 in Science Statistics, Vol. 25, No. 12 (Cat. 88-001-XIB).

*Contact:* *Bert Plaus (613) 951-6347, Bert.Plaus@statcan.ca*

*or:* *Lloyd Lizotte (613) 951-2188 Lloyd.Lizotte@statcan.ca*

### Industrial R&D

Research and development in Canadian industry (RDCI)

Status: *Industrial Research and Development, 2001 Intentions* was released in October 2001, Annual Catalogue No. 88-202-XIB. *Industry R&D expenditures of private non-profit (PNP) organizations, 2000* was released in November 2001 in Science Statistics, Vol. 25, No.10 (Cat. No. 88-001-XIB).

*Contact:* *Bert Plaus (613) 951-6347 Bert.Plaus@statcan.ca*

*or:* *Robert Schellings (613) 951-6675 Robert.Schellings@statcan.ca*

### Research and development in the health field

*Contact:* *Janet Thompson (613) 951-2580 Janet.Thompson@statcan.ca*

## *Human resources and intellectual property*

### The higher education sector

Intellectual property commercialization in the higher education sector

Status: The survey is in the field. Results are expected by March 2002. A sample questionnaire is available for download from the Statistics Canada Web site. See page 2 for instructions on downloading questionnaires.

*Contact:* *Cathy Read (613) 951-3838 Cathy.Read@statcan.ca*

### Federal intellectual property management

Federal science expenditures and personnel 2001-2002, intellectual property management, fiscal year 2000/2001

Status: The survey is in the field. Results are expected by March 2002. A sample questionnaire is available for download from the Statistics Canada Web site. See page 2 for instructions on downloading questionnaires.

*Contact:* *Michael Bordt (613) 951-8585 Michael.Bordt@statcan.ca*

## *Advanced technologies*

### Innovation and advanced technologies and practices in the construction and related industries

Status: A report written by Anthony Arundel on advanced manufacturing technologies has been released. Free of charge and available on the Statistics Canada Web site. See page 2 for instructions on downloading our research papers.

*Contact: Frances Anderson (613) 951-6307 Frances.Anderson@statcan.ca*

## *Innovation*

### Innovation in manufacturing

*Contact:* *Brian Nemes (613) 951-2530 Brian.Nemes@statcan.ca*

### Innovation in services

Status: A report is in progress on the innovative capacity in the services sector. The likely release date is April, 2002.

*Contact: Daood Hamdani (613) 951-3490 Daood.Hamdani@statcan.ca*

## *Biotechnology*

### Biotechnology use and development survey - 1999

Status: A working paper, *Canadian biotechnology industrial activities: features from the 1997 Biotechnology Survey* (Cat. No. 88F0006 XIFO1012, free) was released in August 2001. Enquiries pertaining to this paper can be made to Namatié Traoré, (613) 951-4489.

*Contact: Antoine Rose (613) 951-9919 Antoine.Rose@statcan.ca*

## *Knowledge management practices*

### Survey of knowledge management practices, 2001

Status: Information has been collected. Data release and a preliminary paper are expected to be available in April 2002.

*Contact: Louise Earl, (613) 951-2880, Louise.Earl@statcan.ca*