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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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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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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 September 2000, there were:

- Ten titles in *Fee publications ($),*
- *Eight research papers,*
- *35 working papers, and*
- *22 questionnaire.*

Use and planned use of advanced technologies and advanced practices in the construction sector

The first survey on innovation, advanced technologies and practices in the Canadian construction sector was recently conducted. Five types of functional technologies were studied: 1) communications; 2) new materials; 3) on-site plant and equipment; 4) advanced systems; and 5) design technologies. As well, five types of functional practices were investigated: 1) computerization; 2) quality practices; 3) organizational practices and 4) business practices. This article presents findings from the survey.

A new working paper, *Innovation Advanced Technologies and Practices in Construction and Related Industries: National Estimates*, is the first of a series of studies that results from a joint 3-year collaborative project between the Institute for Research in Construction of the National Research Council of Canada and the Science, Innovation and Electronic Division of Statistics Canada. The objective of the project is to measure, understand and assess innovation, advanced technologies and practices of the Canadian construction sector with a view to developing new policies and programs.

Over the last decade, innovation and advanced technology surveys have been carried out in many countries, including Canada. For the most part, the surveys have concentrated on the manufacturing sector and, more recently, on the services sector, but little work has been done on surveying the construction sector. This article presents findings of the first survey, carried out by Statistics Canada, of innovation, advanced technologies and practices in the Canadian construction sector.

As the production processes in construction are significantly different that those of the manufacturing sector, listings of advanced manufacturing technologies that are currently used were not considered to be appropriate descriptors. Consequently, a classification of advanced technologies and advanced practices that are specific to the construction sector was developed. Five types of functional technologies were identified: communications technologies; new materials; on-site plant and equipment; advanced systems; and design technologies (Table 1).

Note: Revenue size classes used are:
- Small: $50,000 - $999,999
- Medium: $1 million - $9,999,999
- Large: $10 million and over

Figure 1. Functional Advanced Technology Use by Revenue Size

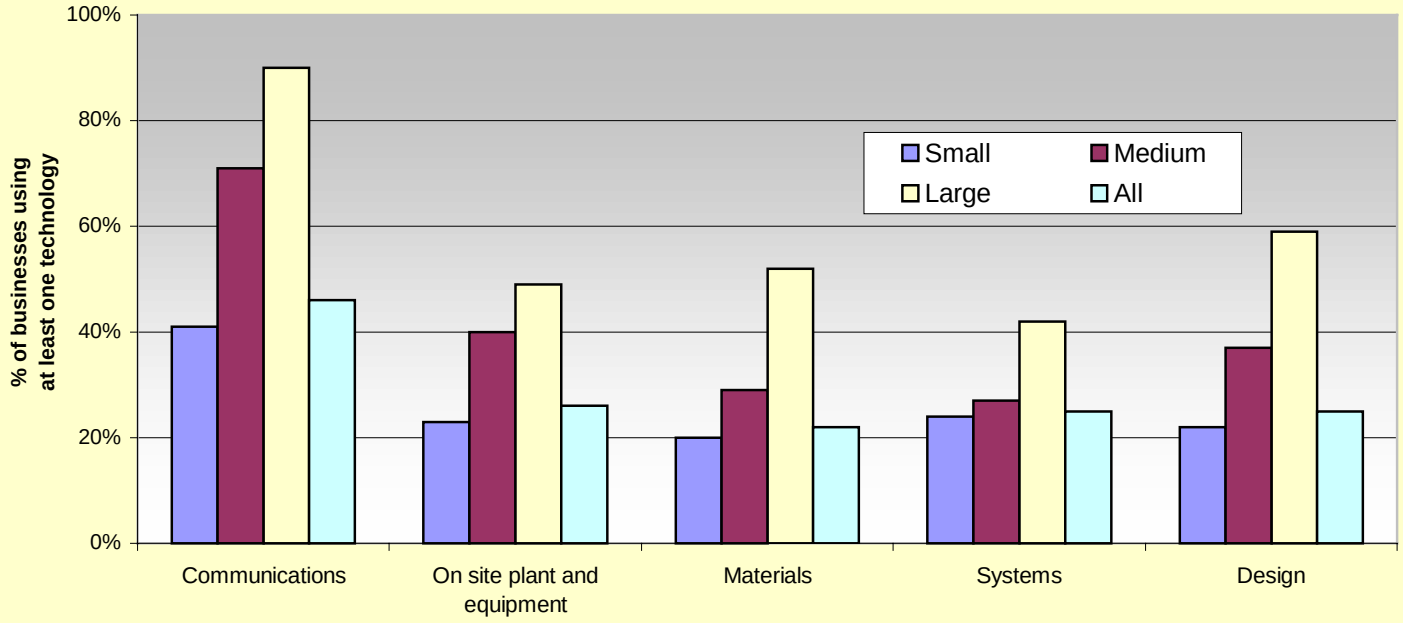


Table 1. Advanced technologies categories

Communications technologies
E-mail
Company computer networks
Digital photography for progress reporting
Office-to-site video links
On-site plant and equipment
Laser guided equipment
Automated systems/programmable machines
GPS (Global Positioning System)
Materials
High performance concrete
Composite materials
Recycled plastic components
Advanced systems
Remote sensing and monitoring systems
Preassembled air, water, power distribution systems
Deconstruction and reuse systems
"Clean room" technology
Bio-remediation clean-up
Design technologies
Modelling or simulation technologies
Computer aided design
Electronic exchange of CAD files

Table 2. Advanced practices categories

Computerization
Computerized project management/scheduling
Computerized inventory control
Computerized estimating software
Quality practices
Quality certification
Organizational practices
Strategic plan
Evaluation of ideas to develop company option
Documentation of technology improvement
Market analysis
Business practices
Design-build contracts
Long term working arrangements
Post-commissioning inspection and maintenance contracts
Build-operate-transfer contracts

Communication technologies lead

Of the five types of technologies, communications technologies have the highest percentage of use (46% of businesses), as indicated by business use of at least one of the technologies regrouped in each category. One in four businesses used at least one technology in the categories of on-site plant and equipment, systems, and design. One in five used new materials. The percentage of businesses using at least one technology in a given category increases with revenue size in all five categories of technologies (Figure 1).

Figure 2. Use and Planned Use of Advanced Technologies

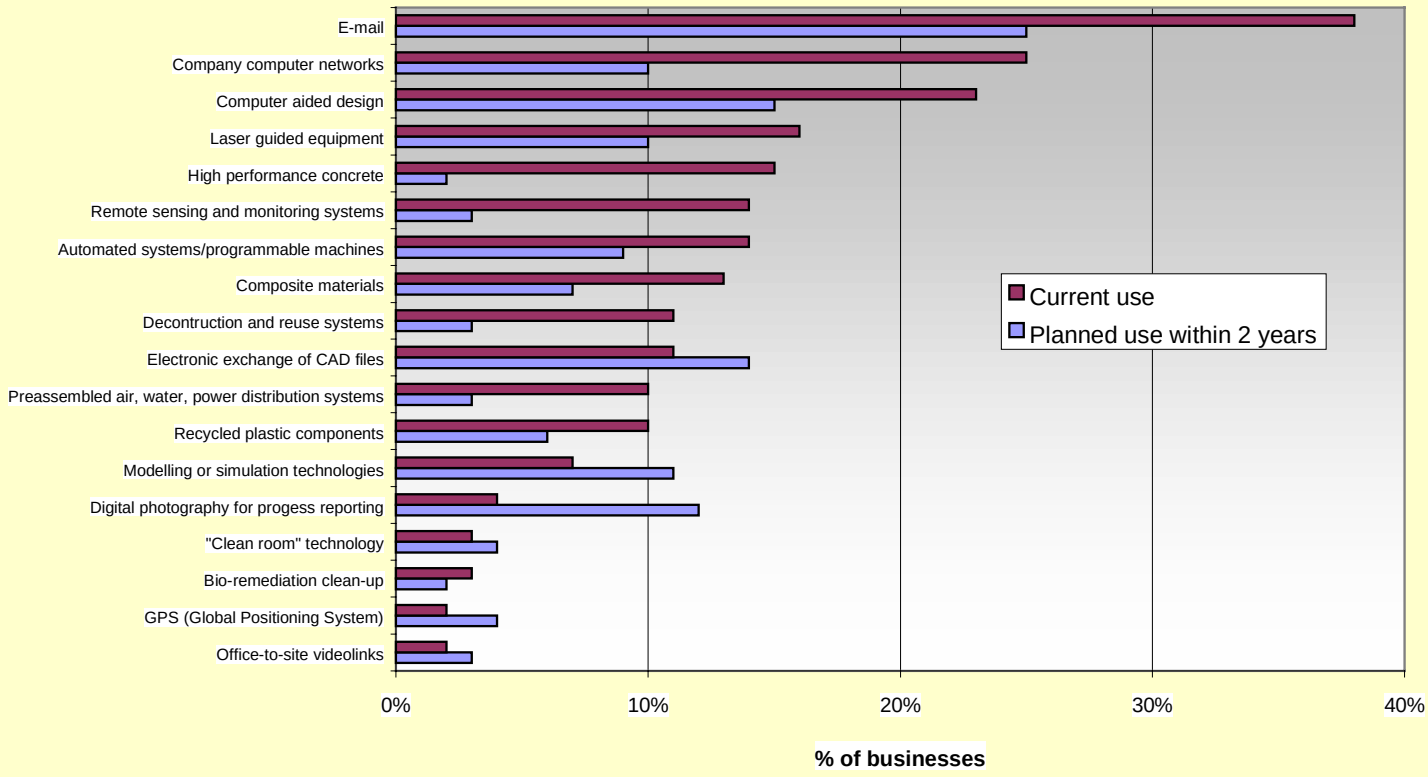


Figure 3. Functional Advanced Practices Use by Revenue Size

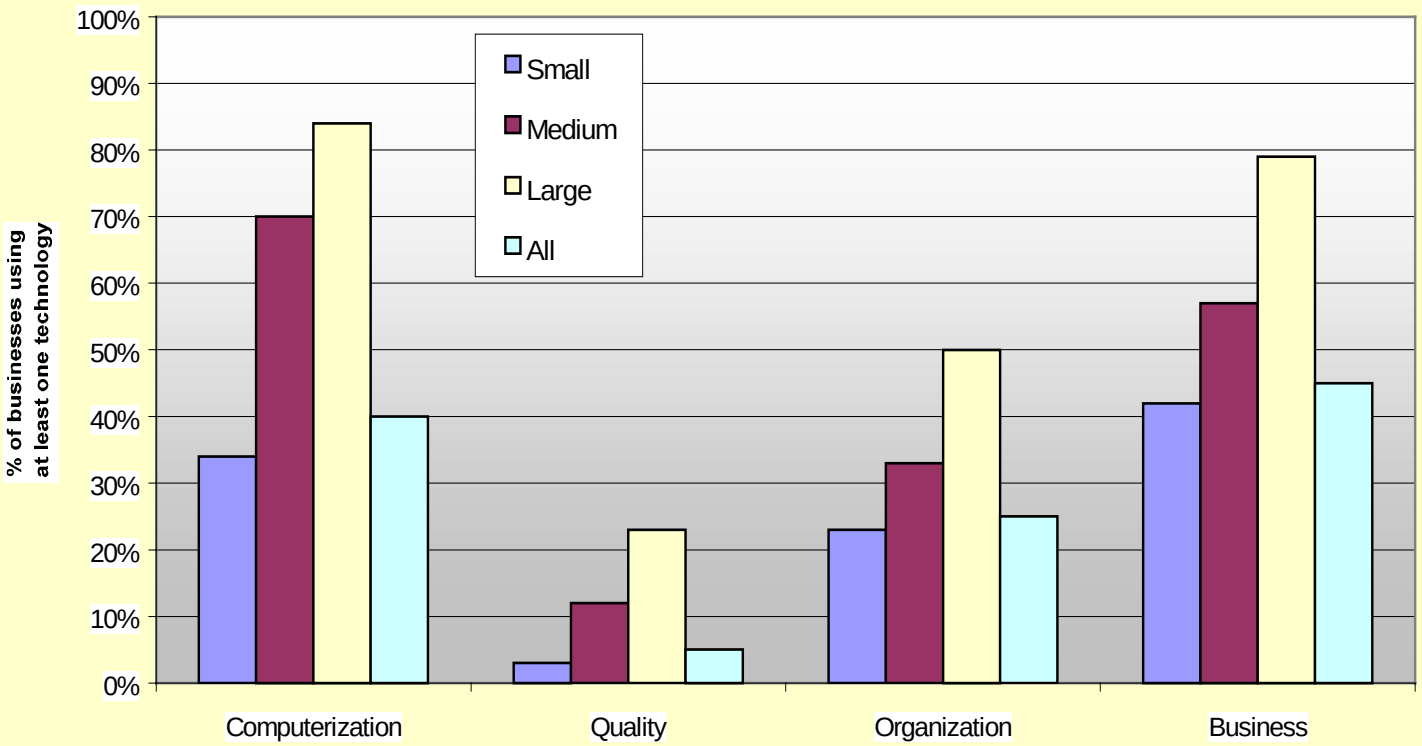
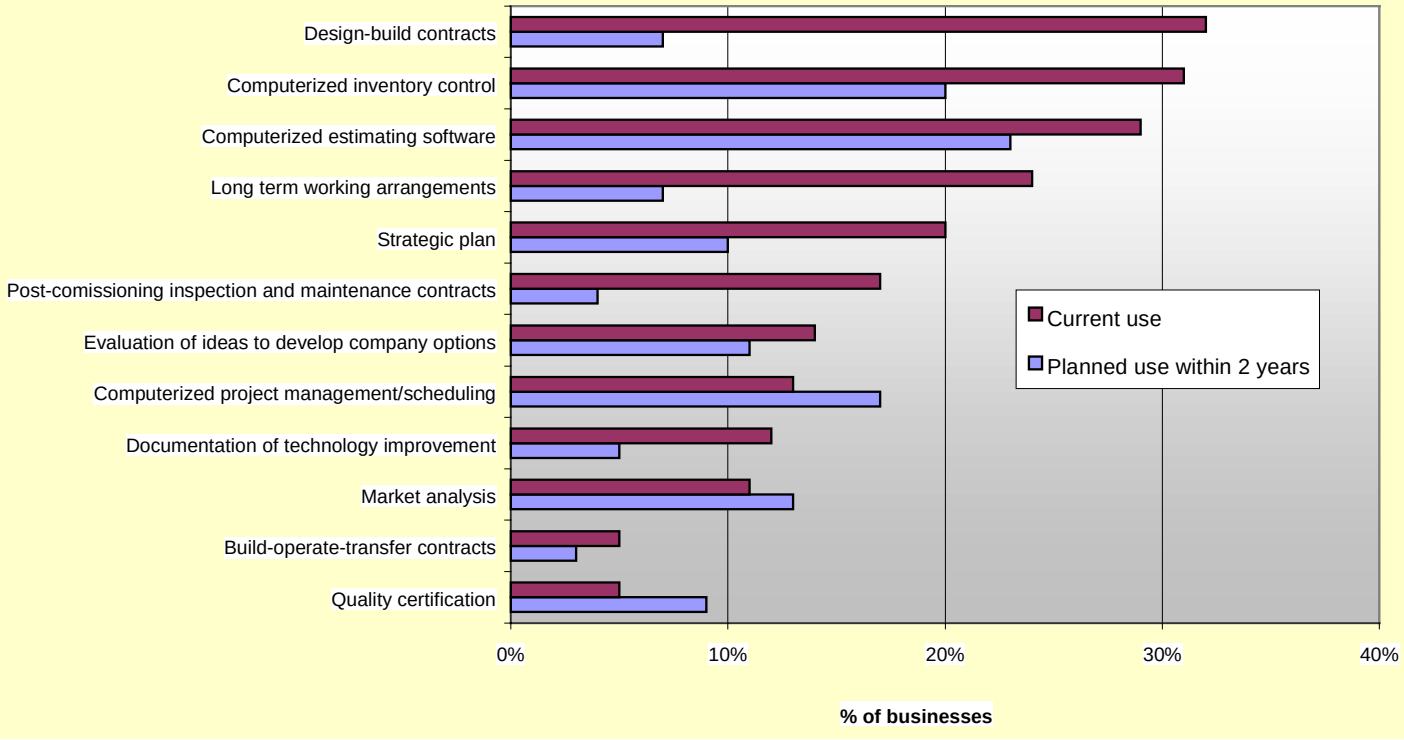


Figure 4. Use and Planned Use of Advanced Practices



Impact of computers

Of all the technologies listed in the survey, three computer related technologies had the highest percentage of use: e-mail (38%), company computer networks (25%) and computer aided design (23%). Planned use of technologies within two years is also highest for a number of computer related technologies: e-mail (25%), computer-aided design (15%), electronic exchange of CAD files (14%) and digital photography for progress (12%) (Figure 2).

The relatively higher percentage of use and planned use of communications technologies and design technologies can be explained, in part, because all businesses in construction could potentially use these technologies. Other types of technologies, for example, bio-remediation clean-up or "clean room" technology, have the potential to be used by only a limited set of businesses.

Functional practices

The listing of advanced practices (Table 2) includes four functional practices: computerization, quality, organizational and business. Of these four functional advanced practices categories, 4 of 10 businesses used at least one communication and business practice, 1 in 4 used at least organizational practice. Only 5% used the one quality practice that was listed. The percentage of businesses using at least one practice increases with revenue size in all four categories of practice (Figure 3).

Advanced practices

The three advanced practices with the largest percentage of business using them, each with approximately one third of businesses, are: design-build contracts, computerized inventory control and computerized estimating software. Planned use of the last two of these practices for the next 2 years is the highest among all practices (at 20% and 23% respectively). Planned use of design-build contracts is relatively lower at 7% (Figure 4).

There are three practices where the percentage of planned use exceeds current use: computerized project management/scheduling systems, quality certification, and written market analysis report to evaluate needs/opportunities.

Further information: Frances Anderson, Indicators Development Section, SIEID, Statistics Canada. (613) 830-5394 Frances.Anderson@statcan.ca or Susan Schaan (613) 830-1953, Susan.Schaan@statcan.ca.

Improvements in the estimation of higher education research & development

The growing trends towards a knowledge-based economy have impacted the way research is funded and performed in Canadian universities. Statistics Canada has initiated a three-year plan that should yield substantially improved estimates of both dollar values and personnel counts in this sector.

The manner in which research is performed and funded in Canadian universities and research hospitals has evolved in recent years. With the transition toward a knowledge-based economy, more and more university research is being performed outside traditional academic departments in affiliated centres, institutes or hospitals, often by full time researchers who do not hold a traditional academic appointment and whose research activities may not be captured in current data. Yet quality estimates of R&D activities by this sector are of increasing importance to policy makers, to the major funders of these activities, and to the performing institutions themselves.

In the Spring of 1999, the former General Secretary of the Natural Sciences and Engineering Council, Ms. Mireille Brochu, was retained to prepare a paper on this topic to stimulate and focus discussion about it. Ms. Brochu's paper was the principal agenda item at a conference of professionals in the university and health research fields in September 1999. Based on strong support for the improvement initiative, a Working Group was formed in the fall, met through the winter, and delivered its recommendations in the spring of 2000. The recommendations cover six major areas including sponsored research, the other costs of research, R&D personnel, health expenditures on R&D, improvements in information dissemination vehicles, and U.S. and international comparisons.

Statistics Canada has created a three-year plan to operationalize as many of the recommendations as feasible. With financial assistance and advice from the three federal granting councils and Industry Canada, work has begun on substantial revisions to the methods for calculating the dollar value estimates for higher education R&D. These estimates, based on the new formulae, are expected out this fall. In the medium term, Statistics Canada will focus its attention upon the completion of personnel estimation methodologies in higher education and health R&D, upon better information dissemination vehicles, and upon U. S. and international comparisons.

Further information: Paul McPhie, Assistant Director, SIEID, Statistics Canada, (613) 951-9038 Paul.McPhie@statcan.ca

Commercialization of federal government and university research

Throughout the 1990s, Canadian universities have taken out patents, spun off companies and licensed their technologies at an ever-increasing rate. The federal government has been playing the same game for a lot longer.

For the past two years, Statistics Canada has conducted surveys of intellectual property management in both the higher education sector (see *Patent or perish: universities are more inventive than ever*, **Innovation Analysis Bulletin**, Vol. 1, No. 1) and in the federal government. Despite their different operating environments, both are striving to promote applied research.

Universities and federal government departments certainly have unique mandates: universities teach and conduct research to advance knowledge, governments legislate and regulate. Science and technology is one area where there is a high degree of common ground and cooperation. The federal government has developed an intricate network of specialized research establishments such as NRCAN's Canadian Explosive Research Laboratory in Ottawa and Agriculture and Agri-food Canada's Dairy and Swine Research and Development Centre in Lennoxville, Quebec. The main mandates of these establishments are to conduct research to support the government's monitoring and regulatory functions.

For this reason, much of the federal government's research is not commercially oriented. Furthermore, some federal agencies prefer to publish their applied research results immediately rather than to exploit the commercial benefits.

Similarly, most research at Canadian universities is not focussed on immediate economic benefits. An increasing amount, though, is conducted in collaboration with industry with the goal of developing new commercial products.

Universities have each developed their own policies and approaches to research and to IP management. Several have no policies on IP management while others assign all rights automatically to the inventor or innovator. In others, the institution itself, by default, owns any IP created at the institution. The latter is similar to the federal government's approach.

Table 1. Federal natural science-based departments and agencies covered in 1999 survey

Agriculture and Agri-food Canada
Canadian Food Inspection Agency
Canadian Space Agency (note: 1998 data were were used)
Communications Research Centre (Industry Canada)
Department of Fisheries and Oceans
Department of National Defense
Environment Canada
Health Canada
National Research Council
Natural Resources Canada
Transport Canada

Points of comparison

Of the 84 universities surveyed in last year's Survey of Intellectual Property Commercialization in the Higher Education Sector, 1999, about half reported having filed patent applications within the past five years.

Of the 11 natural science-based departments surveyed on behalf of their 141 research establishments (see Table 1), all reported having received patents within the past five years.

In fact, the number of active patents held by the federal government exceeds those of universities. In 1999, universities reported 1,826 active patents whereas the federal departments claimed 1,946.

Table 2. Intellectual property management indicators, 1999

	Federal departments	Universities
Resources for IP management		
Full time equivalents (FTEs) for IP management	66	169
Expenditures on IP management ($ million)	8.5[r]	21.0
Invention reports	113	829
Patents issued		
Canada (%)	20.2%	12.0%
US (%)	59.6%	51.7%
Other foreign (%)	20.2%	34.3%
Unspecified (%)	0.0%	2.0%
Total patents (number)	**89**	**325**
Total patents in force	1,946	1,826
New licenses		
Canadian (%)	84.3%	50.0%
US & foreign (%)	15.7%	39.4%
Unspecified (%)	0.0%	10.6%
Total new licenses (number)	**191**	**218**
Royalties		
Canadian (%)	39.2%	31.5%
Foreign (%)	22.5%	47.0%
Unspecified (%)	38.3%	21.5%
Total ($ millions)	**12.0**	**18.9**
Spin-offs (total historical Reported)	**48**	**454**

Sources:

Statistics Canada, 2000, *Survey of intellectual property commercialization in the higher education sector 1999*, SIEID working paper ST-00-01, Cat. No. 88F0006XIB00001.

Statistics Canada, 1999, *Federal science expenditures and personnel 1999/2000, Intellectual property management fiscal year 1998/99*. SIEID survey.

In 1999, universities spent $21.0 million to manage their IP and received $18.9 million in royalties for licenses. In comparison, the federal government spent only $8.5[r] million on IP management for a return of $12 million in royalties. Historical data are not available to show whether or not the government spent more on IP management when the licenses were first executed.

Loyalties and royalties

Licensing a patent is only one step towards realizing its eventual social and economic benefits. A company can license a technology, combine it with another, successfully market it and thereby reap great benefits. If the company licensing the technology is Canadian, it is more likely that the benefits will remain in Canada.

In 1999, half of the 218 new licenses issued to universities went to Canadian companies. The federal government issued 84% of its new licenses in 1999 to Canadian companies. This tendency is reflected in the sources of royalties for previous licenses where universities receive 31.5% of their royalty income from Canadian sources. The federal government receives 39.2% of its royalty income from Canadian sources.

Table 2 provides further comparisons of IP management in the federal government and universities. Both surveys will be conducted again in 2001.

A paper by Cathy Read, titled Survey of Intellectual Property Commercialization in the Higher Education Sector, 1999, is available on the Statistics Canada Web site. The paper also provides additional information on IP management in university-affiliated research hospitals. Please see instructions on page 2 for downloading SIEID working papers.

Further information: Michael Bordt, Chief, Knowledge Indicators Section, SIEID, Statistics Canada, (613) 951-8585
Michael.Bordt@statcan.ca

Why do the surveys of innovation and R&D diverge?

Surveys of innovation and R&D provide divergent data on R&D. This note places the differences in perspective for a better appreciation of the relationship between R&D and innovation.

Research and Development in Canadian Industry (RDCI) is the standard reference for R&D data. Recently, other surveys—Survey of Innovation in Manufacturing 1999 (SIM99), Survey of Advanced Manufacturing Technologies 1998 (AMT98) and Survey of Innovation in Services 1996 (SIS96)—have also provided information on some aspects of R&D. Figure 1 shows the propensity to perform R&D, i.e., number of R&D performers divided by the total number of firms or establishments from each source. The gap is very large with respect to the manufacturing sector.

The factors contributing to the divergence are listed in Table 1 along with the likely direction (- for underestimation and + for overestimation) and size (increasing with the number of times a sign appears) of the bias. The equality sign (=) indicates the bias is insignificant.

The RDCI uses the firm as the unit of observation or measurement which is the international standard for the surveys of R&D and innovation. SIM99 is an establishment-based survey although establishments belonging to each firm were bunched into groups or entities. One questionnaire was sent out per entity in the sample. As R&D is a corporate function it is not possible to ascribe it to a single establishment or entity. If the firm performed R&D and all entities reported it, the number of R&D performers would be inflated.

AMT98 sheds some light on the size of overestimation. This survey, also based on the establishment, minimized double counting by (a) sending questionnaires directly to the establishments drawn in the sample and (b) asking whether the parent company performed R&D. It yielded a propensity to perform R&D of 49 per cent versus 58 per cent from SIM99. Expressed

Figure 1: Comparisons of R&D Performers: R&D and Innovation Surveys

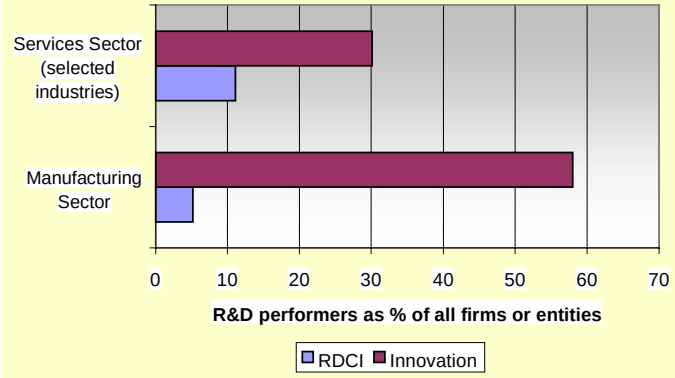
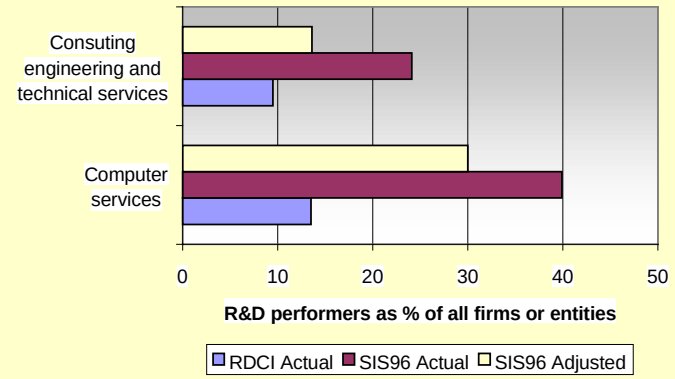


Figure 2: R&D Performers in R&D and Innovation Surveys, Selected Service Industries



in terms of firms, using a factor of two establishments per firm, the figure reduces to 25 per cent. The difference in the timing of the two surveys matters little because they were conducted just one year apart and the number of R&D performers changes little from year to year.

Further, the absence of definition in SIM99 could have resulted in respondents interpreting R&D broadly. The sequence of the questions in the questionnaire reinforces the likelihood that such activities as feasibility studies and marketing research, which RDCI explicitly excludes were included in SIM99.

The gap with respect to services is much smaller, which is a reflection of the similarity of methods and definitions employed in RDCI and SIS96. The divergence is largely in the computer services industry and the consulting engineering and other technical services industry, but is substantially reduced when appropriate adjustments are made (Figure2).

Further information: Daood Hamdani, Chief, Innovation, Technology and Jobs, SIEID, Statistics Canada, (613) 951-3490

Daood.Hamdani@statcan.ca

Table 1. Selected contributors to divergence in data: R&D and innovation surveys

Item	R&D in Canadian Industry (RDCI)	Survey of Innovation (Manufacturing) 1999 (SIM99)	Survey of Innovation (Services) 1996 (SIS96)
General	Census	Sample survey	Census; sample for some industries
Periodicity	Annual	Occasional	Occasional
Reference period	Fiscal year	Three fiscal years, 1997-99	Three fiscal years, 1994-96
Source of Frame of Population	Administrative records and Business Register	Annual Survey of Manufacturers (ASM) 1997; excludes businesses entering in 1998 and 1999. **Bias (--)** for fast-paced industries	Business Register (BR) of Sept. 1996; and CRTC* and OSFI**, Oct. 1996. Bias (-).
Target population	All R&D performers.	Establishments and firms which in 1997 had revenue>$250,000, employees>19, and responded to ASM. Fast-growing firms and R&D performers under-represented**. Bias (--).**	Census or near census for most industries; for others, all records on BR with one or more employees. **Bias (=).**
Data collection	Following the assessment of tax incentive claims. Trade-off between timeliness and complete coverage. **Bias (-).**	Completed in Fall 1999, before the end of the fiscal year March 2000. **Bias (-).**	Spring 1997**. Bias (=).**
Unit of observation or measurement	Firm	Groups of establishments. **Bias (-).**	Firm; establishment for three professional service industries. **Bias (-)**.
Reporting Unit	Same as unit of observation with a few exceptions. **Bias (-).**	Firm (head office). **Bias (++++)**	Same as unit of observation. **Bias (-)**
Definition	International standard	No definition provided. **Bias (+++).**	International standard. **Bias (=)**.
Questionnaire Design	**Bias (=)**	**Bias (++++).**	**Bias (=)**
SIC	1980 SIC	Mix of 1980 SIC and NAICS.	1980 SIC
Overall bias	**(-)**	**(++++)**	**(+)**

* Canadian Radio-television and Telecommunications Commission. ** Office of the Superintendent of Financial Institutions.

Explaining Rapid Growth in Canadian Biotechnology Firms

Biotechnology companies in Canada are constantly developing potentially new products. The cost of this research and development is exceptionally high; leaving most developing biotechnology firms financially exhausted. To ensure growth, it is necessary to adopt the right strategies and mix of products.

In the last twenty-five years, biotechnology has emerged to capitalize on the extraordinary development of molecular biology, genetics and biochemistry that took place in the Post war period. Several thousand companies across the world, including nearly 300 in Canada have created or are developing thousands of new therapeutic compounds, hundreds of diagnostic kits as well as genetically modified plants, bacteria and animals. However, the cost of such new products and genetically modified organisms is staggeringly high, and most developing biotechnology firms are financially strained. Only a few of them will grow provided they adopt the right strategies and mix of products.

This report is the result of an empirical exploratory study, conducted with the support of Statistics Canada in the summer 1999. The goal of the research was to understand the factors explaining the rapid growth of a small number of biotechnology firms in Canada. For that purpose, some sixty firms were interviewed across the country. We tried to find and join some thirty companies experiencing rapid growth (growth of 50% and over, of total employment and/or sales, between 1994 and 1998, and having crossed the threshold of twenty-five employees and/or $2 million in sales). Twenty-eight of those firms and a control group of thirty-two firms with slow growth or no growth at all, were interviewed.

In the sample, rapid growth was associated with a certain age of the biotechnology firm, usually operating in human health products (an area without the problems of consumers' acceptance that plague both environment, food and agricultural biotechnology. Also, fast-growing enterprises adopted a strategy of patenting major novelties, looked for and obtained venture capital financing, and searched large markets by exporting their products, usually through alliances with foreign corporations. Internal R&D capabilities (and probably some luck) ensured that they did not have major delays in delivering their products, or in moving from one phase to the next.

These survey findings bring some confirmation to both internal growth and competence theories of the firm, as well as the external growth perspectives. Targeting the right niche, patenting, efficient R&D and exporting are all in the area of firm strategy and are impacted by managerial competencies. However, R&D and innovation as such, because they are pervasive, are not exclusive to rapid-growth companies. Product development efficiency, though, is related with fast growth. The importance attributed to lack of skills as a major obstacle to growth also supports internal growth theories, including the original formulation by Edith Penrose: top managers are in short supply, and limit the growth of the firm.

External growth theories also receive strong confirmation: access to capital, usually obtained either through venture capital or strategic alliances, is a major growth factor. The vast majority of the firms considered that both alliances and venture capital were major growth factors. The statistical analysis brings additional evidence in favour of this perspective: both variables contribute to explain rapid growth. Marketing alliances with partners in the United States and/or overseas with Western Europe seemed mandatory for companies having completed the development of their products.

Even in a difficult financial environment, companies can improve their chances of rapid growth. The following conclusions and recommendations can be derived from this study.

1. Companies should patent their inventions as a way to signal the financial community of the novelty of their future products, thus their exclusivity. Venture capital is much easier to obtain when the companies possess patents, and venture capital is a major growth factor in biotechnology.

2. Avoiding major delays by conducting R&D on several products, not simply one, and eventually abandoning dead ends. One-product firms are usually too risky for venture capital. Mergers with other small biotechnology firms working in compatible areas can help to increase the chances of having patents, thus venture capital, augment visibility and critical mass, and obtain larger IPOs.

3. Targeting export markets: the Canadian market alone is too small to support any biotechnology product. These are knowledge-intensive products subject to economies of scale (it pays to produce the knowledge once and to sell it embodied as many times as possible). Going for export markets seems unavoidable.

4. Looking for venture capital: Venture capital provides not only cash to firms but also management and financial services, as well as credibility to the emerging firm.

5. Conducting alliances, but timing them. Alliances may procure substantial resources to emerging biotechnology companies. However, alliances are not always successful. Too early an alliance can lead to contracts where the biotechnology firms loses most of the benefits of its innovation although conversely, it can help a cash-strapped firm. If the alliance comes too late the biotechnology firm may already find itself in a weak position due to cash flow problems. The best option for the biotechnology firm is to obtain venture capital, access to the capital market, and organize partnerships at the end of Phase III clinical trials or field tests, when their products are already tested and approved.

6. Planning the IPO; Going public was not a condition of rapid growth. Some of the companies that had obtained access to the stock market had only collected a few million dollars through their IPOs, while others had known major delays and product retargeting after raising substantial amounts from the financial market.

The most compelling notion that arises from this study - in a very competitive market, where hundreds of biotechnology enterprises compete for capital with other new enterprises, the emerging biotech companies should proceed through a sequence of almost unavoidable milestones. These will signal the financial community of the value of the new firm. The milestones include patenting, obtaining venture capital, and launching as early as possible their products in the overseas market, usually with the help of large foreign partners.

Further information: Antoine Rose, Chief, Life Sciences Unit, SIEID, Statistics Canada, (613) 951-9919
Antoine.Rose@statcan.ca.

Biotechnology research and development (R&D) in Canadian industry: a portrait of large R&D performers in 1997

Biotechnology R&D expenditures and funding, among large R&D performers, grew rapidly between 1989 and 1997. R&D in biotechnology is concentrated around the "core firms" that are responsible for 87% of expenditures. Health is the leading sector involved in biotechnology R&D, in terms of expenditures, destination of funding and labour force. While government direct funding for biotechnology R&D decreased, foreign and private funding dramatically increased and contributing to the rapid growth in the emerging services sector contribution to R&D in biotechnology

Biotechnology, a rising activity in the Canadian economy, represents a technology that enables transformation of production processes across a wide range of sectors, including health, agriculture and natural resources. Technological change and innovations, leading to process and product development, depend greatly on R&D activities and investments. Biotechnology R&D aims at improving scientific knowledge using biotechnologies. This R&D may result in the innovative use of biotechnology for improving and/or developing products, plants and animals or the use of micro-organisms.

Using 1997 Industrial R&D statistics, this article examines the level and trends in biotechnology R&D in different industrial sectors. Large performers, with at least $1 million expenditures in R&D, were surveyed. The final sample was 747 firms.

R&D performers

In 1997, 85 large firms performed Biotechnology R&D. These biotechnology R&D performers, accounted for $904 million of R&D expenditure, of which half ($446 millions) was invested in biotechnology. Between 1989 and 1997, total biotechnology R&D expenditure, for large R&D performers, increased from $89 million to $446 million. Biotechnology R&D is concentrated in larger firms, in 1997 75% of R&D occurred in firms with 100 or more employees. Table 1 recapitulates R&D expenditure figures in biotechnology with respect to groups surveyed.

Core firms contribute 87% of R&D expenditures in biotechnology

In 1997 core firms represented 54% of the biotechnology performers and were accountable for 87% of all biotechnology R&D expenditures among large R&D performers. Firms spending 50% or more of their R&D expenditures in biotechnology are referred to as the "core biotechnology firms". A large proportion of the core firms is in the health sector, representing 65% of the total biotechnology R&D expenditures in 1997.

Share of Canadian controlled Biotechnology R&D firms remained steady from 1989 to 1997, while foreign controlled firms share decreased.

Table 1: Total biotechnology R&D expenditures per group, in 1997

	Number of Firms	Biotechnology R&D expenditures in million $	% of total R&D Biotechnology expenditures
Core biotechnology R&D firms* - Health	29	$291	65%
Core biotechnology R&D firms* - Non-Health +	17	$97	21%
Non-core biotechnology R&D firms	39	$58	13%
Total Biotechnology performers	85	$446	100%

* Core = 50% or more of R&D is spent on biotechnology R&D

+ Non-Health = Agrifood, Natural resources, services, chemicals and equipment

Table 2: Biotechnology R&D expenditures, by country of control, 1989 to 1997

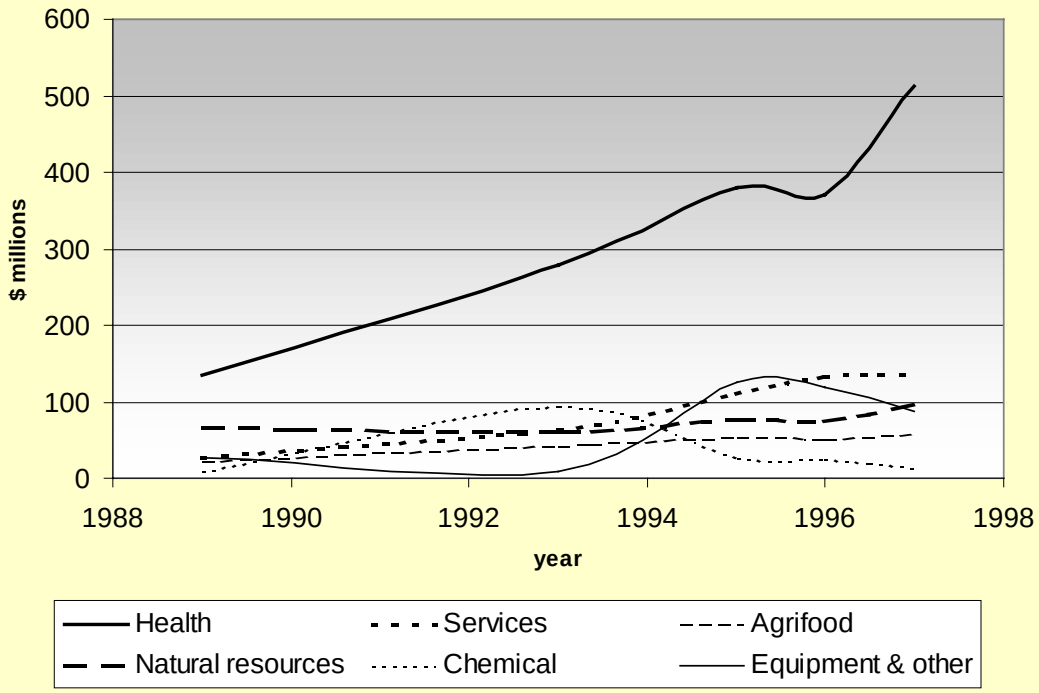
	Biotech R&D expenditures in million $			Percentage distribution		
Country of control	1989	1997	Growth	1989	1997	Change in share
Canada	58	310	21%	65	69	7%
USA	10	46	17%	11	10	-8%
Other countries	21	90	17%	23	20	-14%

Table 3: Sources of biotechnology R&D funding among large performers in 1997, in $millions

	Government	Other Sources	Foreign Sources	Total
Health	6.9	414.4	90.8	512.1
Services	2.7	52.0	80.0	134.7
Natural resources	6.1	89.9	0.2	96.2
Equipment & other	2.4	84.1	1.7	88.3
Agrifood	3.6	46.4	9.2	59.2
Chemical	0.2	8.7	4.7	13.6
Total	**21.9**	**695.6**	**186.7**	**904.1**
% Change 89-97	-41%	67%	84%	69%
% Total in 1997	2%	77%	21%	100%

In 1997, almost 70% of biotechnology R&D was performed by Canadian controlled companies and this proportion has not changed significantly over the five survey years. In the same year, 10% of the biotechnology R&D occurred in firms controlled by the United States and 20% in firms controlled by other countries. Biotech expenditures increased in all cases, but even more in Canadian controlled firms. Figures are shown in Table 2.

Figure 1. Biotech R&D funding per sector



R&D funding

Table 3 presents data on sources of biotechnology funding in different sectors. In 1997, almost 77% of funding sources for R&D in biotechnology came from the private sector and 21% from foreign sources. Since 1989, the government's direct contribution has decreased by over 41%. R&D tax credits and incentive measures are NOT considered direct contributions. Large increases in funding are especially evident in the health and services sectors, which almost tripled and quadrupled respectively from 1989 to 1997.

Foreign R&D funding in the health sector increased by 84% between 1989 and 1997

In the health sector, the average annual growth rate was more than 20%. Total foreign sources of funding have increased by 84% in the same time period, reflecting increasing strategic partnerships between Canadian firms and multinational partners, particularly in the health sector.

Rapid growth in biotechnology R&D funding in the health and services sectors.

Figure 1 displays the evolution of R&D funding per sector and highlights the significant growth in the health and services sectors from 1989 and 1997.

Further information: Antoine Rose, Chief, Life Sciences Unit, SIEID, Statistics Canada, (613) 951-9919 Antoine.Rose@statcan.ca.

Business use of the Internet to purchase and sell

The subject of Internet use is of widespread interest and the extent to which business is engaging in commerce over the Internet is extensively followed. A new survey entitled "Information and Communications Technologies and Electronic Commerce" provides useful indicators of the economy's readiness to benefit from emerging technologies. It reports the extent to which enterprises in the Canadian public and private sectors are using information and communications technologies. Variations across industries are examined, as are differences across the use of technologies. This article reports on one aspect of the electronic commerce - the use of the Internet by Canadian businesses to purchase and sell.

Enterprises that sell over the Internet

Many factors may contribute to the dispersion across industries and organizations in the propensity to sell over the Internet. For example, an established business model for organizations may preclude the use of the Internet as a channel over which to conduct business. If a business has a small number of customers then using an open communications network such as the Internet that can reach a wide market may not be necessary. The Internet is an open communications network in contrast to proprietary networks over which several organizations have been conducting business for some time using Electronic Data Interchange (EDI). The migration of business from a proprietary network to the Internet is an involved and complex process that requires a significant investment of resources. At the time of the survey, October 1999, the migration from proprietary networks to the Internet had not occurred for most industries.

The proportion of enterprises in the private sector that use the Internet to sell goods and services is 10.1% of private sector enterprises (Table 1). Enterprises that use the Internet to sell constitute 17% of economic activity, for the private sector, where economic activity is measured by total operating revenue. Of enterprises that use the Internet, 19.1% use the Internet for the purpose of selling goods or services.

Of all industries in the private sector, the information and cultural industries have the largest percentage of enterprises that use the Internet to sell goods and services (20.1%). Information and cultural industries include businesses that are involved in publishing, broadcasting and telecommunications. Some of these businesses are instrumental in providing the services necessary to use the Internet such as telecommunications carriers, broadcasters and information services.

Table 1. Proportion of enterprises by industry that use the Internet to sell goods or services

Industrial Sector	% of enterprises that use the Internet to sell goods or services	% of economic activity attributable to enterprises that use the Internet to sell	% of Internet user enterprises that use the Internet to sell goods and services
Forestry, Logging and Support Activities *	1.1	0.9	3.5
Mining and Oil and Gas Extraction	7.1	5.2	11.7
Utilities	9.2	9.8	11.1
Manufacturing	14.9	16.3	23.3
Wholesale Trade	13.6	17.1	21.5
Retail Trade	10.9	21.9	27.0
Transport and Warehousing	10.1	21.1	23.0
Information and Cultural Industries	20.1	44.3	22.6
Finance and Insurance	14.7	23.0	22.3
Real Estate and Rental and Leasing	9.5	11.5	20.5
Professional, Scientific and Technical Services	11.5	14.9	14.8
Management of Companies & Enterprises	8.0	3.7	17.1
Admin & Support, Waste Management & Remediation Services	17.3	23.3	31.2
Educational Services Private	17.3	22.2	23.2
Health Care and Social Assistance Private	3.1	6.3	6.6
Arts, Entertainment and Recreation	10.1	9.8	19.7
Accommodation and Food Services	7.9	16.3	24.7
Other Services (except Public Admin)	3.7	5.0	8.3
All Private Sector	**10.1**	**17.0**	**19.1**
Educational Services Public	32.2	43.4	32.4
Health Care and Social Assistance Public	3.1	3.3	3.3
Public Administration	24.7	28.2	25.2
All Public Sector	**14.5**	**23.1**	**15.2**

* NAICS 113, forestry and logging and NAICS 115, support activities for agriculture and forestry are included in forestry, logging and support activities.

Estimates are weighted by revenue for the private sector and by the number of employees for the public sector.

Source: Information and Communications Technologies and Electronic Commerce Survey, 1999

Enterprises in the private educational services and administration and support services sectors that use the Internet reported the second largest percentage of enterprises that use the Internet to sell goods or services (17.3%). In the forestry, logging and support sector, a significantly lower proportion of enterprises report using the Internet to sell (1.1%). For forestry, logging and support activities, among enterprises that use the Internet, 3.5% use the Internet for selling.

For the public sector, 14.5% of institutions use the Internet to sell goods or services. Educational services use the Internet the most for selling and federal and provincial governments use the Internet the second most to sell goods and services. For the educational sector, items sold over the Internet include courses (tuition fees) and course registration for publicly funded educational institutions. Included in the public sector are online sales of data, for example, from Statistics Canada and the online payment of user fees for various services offered by provincial and federal governments.

Proportion of enterprises that purchase over the Internet

The Internet is a viable option considered in making travel arrangements, booking accommodation, purchasing books, searching for employment opportunities and conducting financial transactions. All of these activities are carried out by the sectors for which selling on the Internet is more common than purchasing.

The industries for which the Internet is more popular for purchasing than selling include some industries that are not in the business of selling directly to individuals per se. These include information and cultural industries, professional scientific and technical services and utilities. The bulk of the business transacted by these industries is more likely to be business to business transactions than the transactions conducted in other industries such as retail trade which are more likely to be transactions between business and individuals.

On average, a greater proportion of enterprises use the Internet to purchase goods and services rather than to sell. For the private sector, 13.8% of all enterprises use the Internet to purchase and these enterprises constitute 25.1% of economic activity for the private sector (Table 2). Of enterprises that use the Internet, 26.2% of them use the Internet to purchase goods or services.

In a similar ranking, as that for selling over the Internet, the information and cultural industries ranks first in terms of the proportion of enterprises reporting use of the Internet for purchasing (49.6%).

For the public sector, 44.2% of institutions use the Internet to purchase and 52.0% of economic activity is attributable to those enterprises using the Internet to purchase goods and services. For the public sector, as well, using the Internet to purchase is more popular than it is for selling. This is true for all sectors of the public sector including education, health and federal and provin-

Table 2. Proportions of enterprises that use the Internet to purchase goods or services by Industry

Industrial Sector	% of enterprises that use the Internet to purchase goods or services	% of economic activity attributable to enterprises that use the Internet to purchase	% of Internet user enterprises that use the Internet to purchase goods and services
Forestry, Logging and Support Activities *	7.4	10.6	22.5
Mining and Oil and Gas Extraction	19.3	24.5	31.9
Utilities	24.7	37.7	30.0
Manufacturing	18.9	31.8	29.7
Wholesale Trade	13.9	23.2	22.1
Retail Trade	10.8	15.7	26.7
Transport and Warehousing	10.7	27.8	24.4
Information and Cultural Industries	49.6	53.6	55.7
Finance and Insurance	12.7	39.5	19.2
Real Estate and Rental and Leasing	8.2	11.3	17.7
Professional, Scientific and Technical Services	30.0	39.7	38.8
Management of Companies & Enterprises	12.9	16.8	27.4
Admin & Support, Waste Management & Remediation Services	13.4	17.7	24.2
Educational Services Private	27.2	35.3	36.4
Health Care and Social Assistance Private	9.5	14.4	20.6
Arts, Entertainment and Recreation	12.1	16.5	23.8
Accommodation and Food Services	3.9	8.5	12.3
Other Services (except Public Admin)	6.5	10.3	14.6
All Private Sector	**13.8**	**25.1**	**26.2**
Educational Services Public	60.6	65.5	61.1
Health Care and Social Assistance Public	34.7	37.2	37.3
Public Administration	50.7	59.8	51.8
All Public Sector	**44.2**	**52.0**	**46.4**

* NAICS 113, forestry and logging and NAICS 115, support activities for agriculture and forestry are included in forestry, logging and support activities.

Estimates are weighted by revenue for the private sector and by the number of employees for the public sector.

Source: Information and Communications Technologies and Electronic Commerce Survey, 1999

cial governments. Of institutions in the public sector that use the Internet, the proportion that use it for the purpose of purchasing goods or services is 46.4% of institutions. The public educational services sector has the greatest proportion (60.6%) of institutions that use the Internet to purchase of all industries in the public sector.

Of enterprises that report using the Internet, the industries with the greatest proportion of enterprises that use the Internet to purchase goods or services are in information and cultural industries, professional, scientific and technical services and in private educational services.

Purchasing essential inputs over the Internet

The 1999 survey obtained information about the extent to which the Internet was being used as part of the supply chain of Canadian business. The survey collected the information by asking the following question. Does your organization use the Internet to purchase inputs such as goods or services that are essential to your business? The determination of what constituted essential was left to the respondent.

For all industries in the private sector, 5.8% of enterprises use the Internet to purchase essential inputs (Table 3). This indicates that widespread use of the Internet as a medium over which purchases of goods and services are made has not yet been realized. The industries reporting more than 14% of enterprises purchasing essential inputs over the Internet include information and cultural industries (20.5%), utilities (18.3%) and professional, scientific and technical services (14.8%). In some sectors, the use of the Internet in purchasing is slightly more prevalent than in others; however, the majority of enterprises do not purchase essential inputs over the Internet.

The public sector reports greater use of the Internet with 14.6% of institutions using the Internet for essential input purchases. The largest contributor to this figure is public educational services with 24.3% of organizations reporting using the Internet to purchase essential inputs. Federal and provincial governments are second with 19.7% of institutions reporting purchases of essential inputs over the Internet. Given that more institutions in the public sector use the Internet for purchases than do those in the private sector, this indicates that the public sector may be prepared to move towards an Internet based environment for conducting some transactions.

Some data from this survey have been released by Statistics Canada in the Statistics Canada *Daily* of August 10, 2000. A working paper reporting on more survey results will be released in the fourth week of October 2000.

Further information: Cathy Bakker, SIEID, Statistics Canada, (613) 951-2929, cathy.bakker@statcan.ca.

Table 3. Use the Internet to purchase essential inputs by industry

Industrial Sector	% of enterprises that use the Internet to purchase essential inputs	% of economic activity attributable to enterprises that use the Internet to purchase essential inputs
Forestry, Logging and Support Activities *	1.4	1.2
Mining and Oil and Gas Extraction	7.4	5.1
Utilities	18.3	6.8
Manufacturing	5.5	9.5
Wholesale Trade	5.6	7.2
Retail Trade	5.1	9.0
Transport and Warehousing	4.8	6.2
Information and Cultural Industries	20.5	27.0
Finance and Insurance	5.5	12.7
Real Estate and Rental and Leasing	3.7	4.1
Professional, Scientific and Technical Services	14.8	19.8
Management of Companies & Enterprises	3.3	4.2
Admin & Support, Waste Management & Remediation Services	8.6	6.1
Educational Services Private	11.2	17.3
Health Care and Social Assistance Private	2.3	3.6
Arts, Entertainment and Recreation	5.6	3.1
Accommodation and Food Services	1.4	4.6
Other Services (except Public Admin)	1.5	3.6
All Private Sector	**5.8**	**8.8**
Educational Services Public	24.3	31.9
Health Care and Social Assistance Public	8.4	11.3
Public Administration	19.7	22.9
All Public Sector	**14.6**	**21.3**

* NAICS 113, forestry and logging and NAICS 115, support activities for agriculture and forestry are included in forestry, logging and support activities.

Estimates are weighted by revenue for the private sector and by the number of employees for the public sector.

Source: Information and Communications Technologies and Electronic Commerce Survey, 1999

Mapping innovation and connectedness

Is location important in research and technology? Many researchers have investigated regional innovation and why Silicon Valleys come into existence. The results have been inconclusive. Mapping Statistics Canada's survey data will provide a new approach to analysing this phenomenon.

Statistics Canada is working together with other federal partners to investigate the usefulness of mapping key innovation, connectedness and S&T information. The ultimate goal is to bring many of our indicators into an interactive Geographic Information System (GIS) which would provide a flexible analytical platform.

Statistics Canada manages the Standard Geographic Classification, which defines statistical areas such as census division (CDs), census sub-divisions (CSDs) and census metropolitan areas (CMAs). For many analytical purposes, this level of detail is enough.

Imputing data

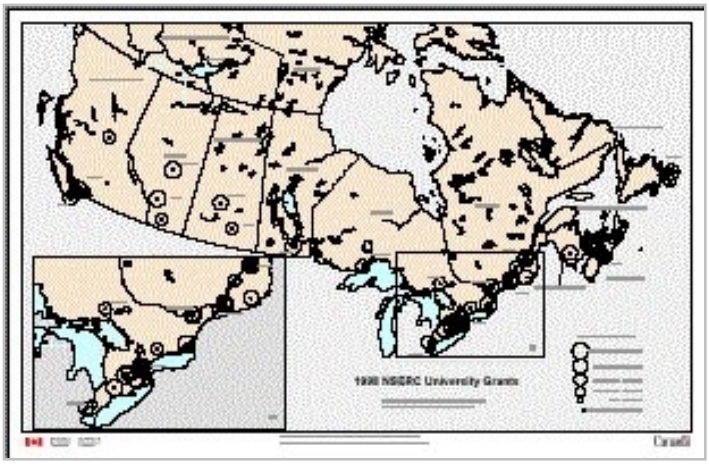
Data are simpler to map if they are derived from the Census or large surveys. Sample surveys, however, are not often mapped since the number of responses in a given small geographic area would not support a reliable estimate of the population.

One approach taken to overcome the limitations of mapping survey data is to generate non-confidential and reliable summaries of the survey data. These summaries, such as propensity to innovate by province and by industry sector, are attached to another database with a larger sample size. In the case of the Innovation Survey 1999, the Annual Survey of Manufacturers (ASM) was used to give a detailed geographic distribution of manufacturing establishments.

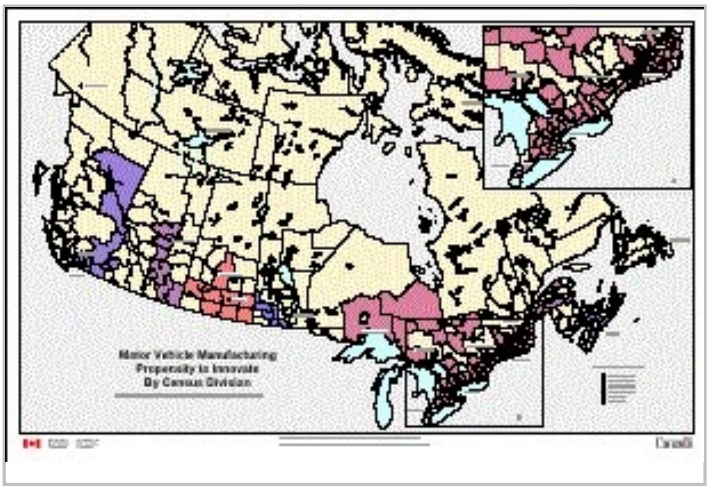
This process makes the assumption that establishments within an industry in any province behave similarly. Regional differences (census divisions, in this case) come about from the varying mixtures of industries.

Sample maps

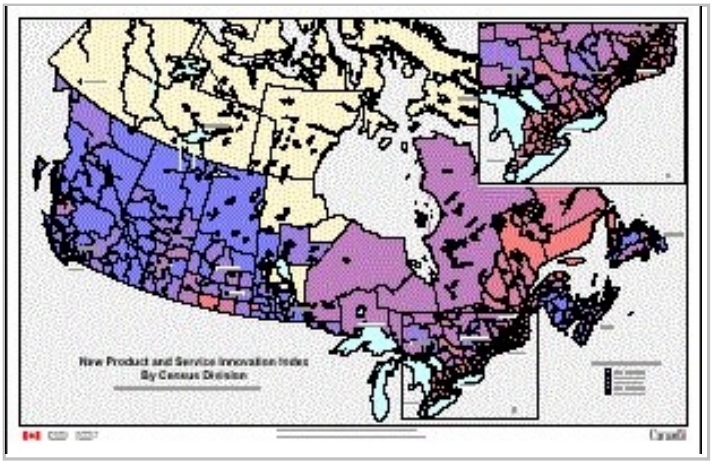
NSERC Grants by University. This is simply a point where the university is located with a circle indicating the value of the grant (new grants 1997).



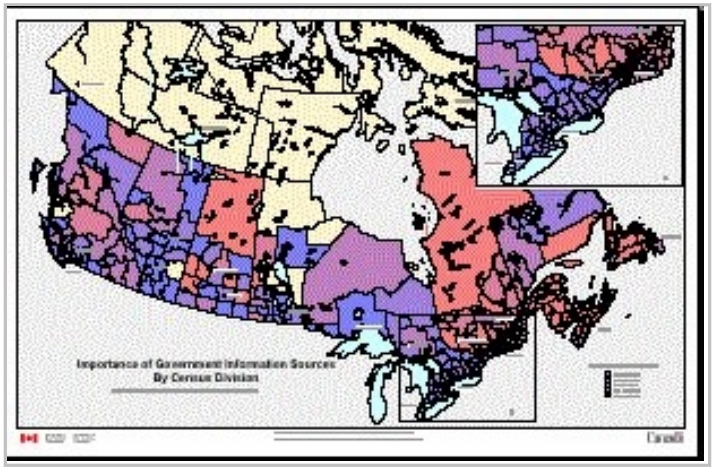
Motor Vehicle Industry Innovation Index. The map below is derived from the *Innovation Survey 1999.* It shows the average propensity to innovate (introduced new product or service within the past 3 years) by province for the motor vehicle (and components, tractors, etc.) industry. CD-level detail is obtained from the ASM by showing only CDs where establishments within that sector exist. For this map and the ones following, orange denotes the highest propensity, dark blue is lowest and pink and light purple are moderate.



Average Propensity to Innovate by Census Division. Given the example in the map above, we can average the figure for all industries in a CD based on the province/industry index obtained from the *Innovation Survey 1999* and the number of establishments per CD by industry obtained from the ASM. This provides a synthetic index of regional innovation.



Importance of Government Information. A similar approach can be taken for any yes/no question on the survey. The example below is the probability that the government is a source of ideas for innovation.



The real benefits of this approach will be realized when this rich set of data is available in an interactive GIS. This will allow overlaying data and zooming in to look at specific areas in more detail.

Further work

Other data sets being explored include:

- **The Census of Population**: We have derived an S&T degree index by census sub-division from the field of study of the highest degree achieved.
- **Research and Development in Canadian Industry (RDCI)**: We are in the process of deriving summaries of sources of funds as well as expenditures on R&D in biotechnology, software and pollution abatement.
- **Federal Government Research Establishments**: these will be mapped at their actual locations classified by the department or agency responsible.

We hope to also bring in information from:

- **The Survey of Advanced Technology in Canadian Manufacturing – 1998,**
- **The Information and Communications Technologies and Electronic Commerce Survey**, and
- **The Biotechnology Use and Development Survey – 1999**.

Other Statistics Canada sources, such as the National Graduate Survey and the Survey of Labour and Income Dynamics, are also being considered for inclusion in the GIS database.

Further information: Michael Bordt, Chief, Knowledge Indicators Section, SIEID, Statistics Canada, (613) 951-8585
Michael.Bordt@statcan.ca

Industrial research and development, 1996 to 2000

The statistics presented here are derived from the 1998 survey of industrial R&D activities in Canada and from Canada Customs and Revenue Agency's administrative data for firms performing or funding R&D under $1 million. In 1997, a decision was made to eliminate the short survey forms in favour of administrative data in order to reduce the response burden. The survey collects information on the R&D spending intentions for 2000, the estimates for 1999 and the actual expenditures for 1998 of corporations performing R&D activities in Canada.

R&D statistics are provided for 46 industries falling under 6 subgroups: Agriculture, Fishing and Logging; Mining and Oil Wells; Manufacturing; Construction; Utilities; and Services industries. The industry breakdown is in accordance with the 1980 Standard Industrial Classification (Catalogue no. 12-501).

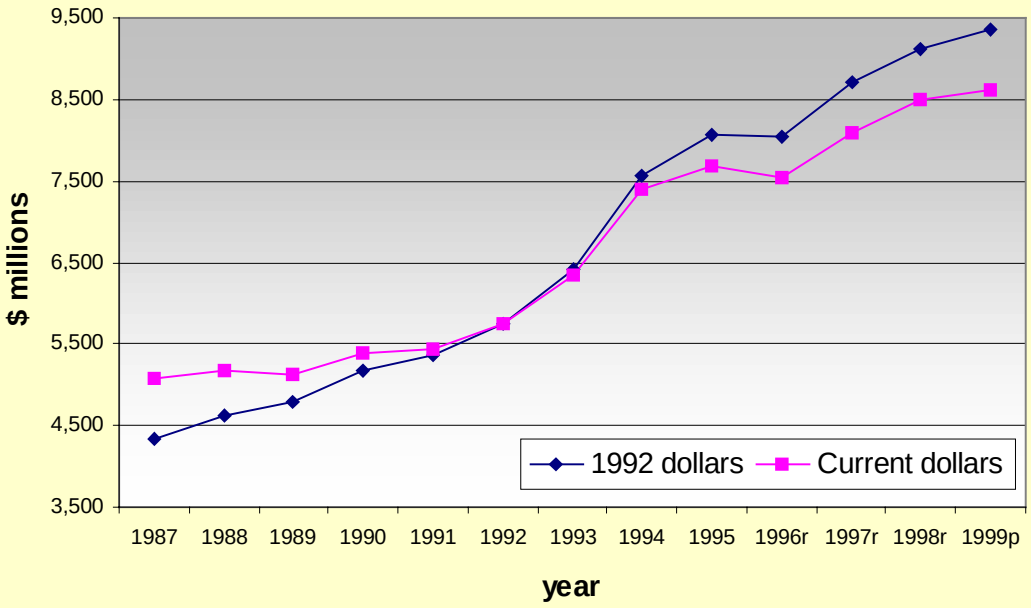
Highlights

- Planned expenditures on research and development (R&D) in Canadian industry were expected to rise to about $9.9 billion in 2000, an increase of 5.8% over 1999. In 1999, there was an increase of 2.7% over 1998. In real terms (after taking into account price increases), growth for 1999 was 1.1% compared to 5.2% for 1998.
- Telecommunications Equipment is the leading industry with 23% of all intramural R&D expenditures expected in 2000, followed by Aircraft and Parts (11%), Engineering and Scientific Services (10%) and Wholesale Trade (7%).
- Over the last five years these leading industries have remained almost the same. Their share of the total intramural R&D expenditures has risen from 44% in 1996 to a planned 51% in 2000.
- The highest percentage increases in intramural R&D expenditures over the period of 1996 to 2000 were achieved by Other Transportation Equipment (160%), Electronic Parts and Components (90%) and Transportation and Storage (78%). Conversely, Services Incidental to Mining

(-83%), Fishing and Trapping (-63%) and Other Mines (-60%) have experienced the strongest declines.

- The principal source of funding in 1998 came from the performing business enterprises themselves. They financed 64% of the total R&D expenditures. Source of funding data are available up to the actual year 1998. Since 1986, this proportion has remained basically unchanged. Funding of the industrial R&D from foreign sources was equivalent to 27% of the total industrial R&D while the Federal Government's contribution was 3% and other Canadian sources accounted for 6%.

Figure 1. Research and Development in Canadian Industry, 1987 to 1999[p]



The deflator for 1987-1998 is the implicit price index of the GDP: 1992=100

- Federal Government financing was concentrated in the Aircraft and Parts industry which received $140 million, Engineering and Scientific Services which received $32 million, Other Electronic Equipment (excluding Telecommunication Equipment and Electronic Parts and Components) which received $21 million in federal funding. Foreign funding was particularly significant in the Telecommunication Equipment industry, where it amounted to over $1.5 billion, and in the Business Machines industry ($211 million). Other Canadian sources of funds included $301 million made available by Canadian corporations to their R&D affiliates, $174 million paid by Canadian corporations for R&D undertaken by unaffiliated companies and research institutes, and $57 million funded by provincial governments.

- Most of the industrial R&D in Canada was performed in Ontario and Québec. About 57% of all R&D in 1998 was performed in Ontario, where Electrical and Electronic Products industries are particularly prominent. In fact, 66% of the industrial R&D performed in the Electrical and Electronic industries (Telecommunication Equipment, Electronic Parts and Components, Other Electronic Equipment, Business Machines and Other Electrical Products) took place in Ontario. In Québec, the Aircraft and Parts industry is of major importance, with 47% of total R&D expenditures by this industry in 1998 occurring in that province.

- In 1998, of the 7,171 firms that performed R&D, 406 were foreign controlled and they accounted for 34% ($3,118 million) of the total intramural R&D expenditures, compared to $5,993 million for Canadian-controlled companies.

- The number of workers engaged in industrial R&D in 1998 decreased by 7% (5,663 workers) from the previous year. Those with a university degree decreased by 5%, while technicians and others (those without a degree or technical certificate) decreased by 10%.

These data were recently published in the service bulletin *Science Statistics*, Cat. No. 88-001-XIB, vol. 24, no. 3. Please refer to the service bulletin for detailed tables.

Further information Bert Plaus, Chief, Science and Innovation Surveys Section, SIEID, Statistics Canada (613) 951-6347 Bert.Plaus@statcan.ca.

What's new?

Recent and upcoming events in innovation analysis.

Science and Innovation

S&T Activities

Federal and provincial S&T

Federal science expenditures

Status: A service bulletin, ***Science Statistics***, Cat. No. 88-001, volume 24, no.4 was released. An annual publication, ***Federal Scientific Activities***, Cat. No. 88-204 will be released in December 2000.

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

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

Industrial R&D

Research and development in Canadian industry

Status: A service bulletin, Science Statistics, Cat. No. 88-001, Vol. 24 No. 3 was released in September 2000.

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

Human Resources and Intellectual Property

The higher education sector

Intellectual Property Commercialization in the Higher Education Sector

Status: We are continuing analysis of the 1999 survey. A working paper is expected by March 2001.

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

Federal intellectual property management

Federal Science Expenditures and Personnel 1999-2000, Intellectual Property Management, Fiscal Year 1998/99

Status: Data from the 1999 survey were released in September.

Contact: *Claire Simard (613) 951-1916*
Claire.Simard@statcan.ca

Human resources in science and technology

Status: We are working with Statistics Canada's Centre for Education Statistics on an assessment of *Choices and Performance: Determinants of Science and Technology Skills*. A report should be available in mid-2001.

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 working paper on this topic is forthcoming in October 2000.

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

Advanced technologies in natural resource industries

Status: The survey is under development.

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

Innovation

Innovation in manufacturing

Status: Data from the 1999 survey were released on January 31. A working paper will be released in the late fall.

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

Innovation in services

Status: ***Interaction Between Knowledge and Innovation: Statistical Evidence*** will be released in the fall. A preliminary version of this study was an invited presentation at the 4th International Conference on Technology Policy and Innovation, Curitiba, Brazil, August 2000.

Work is also under way on two other projects:

Measuring Novelty: Additional Indicators of Innovation

Status: Preliminary results of this study were presented at the International Conference on Economics and Socio-economics of Services, Lille, France, June 2000.

R&D Data: Why R&D and Innovation Surveys Diverge

A paper is forthcoming.

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

Biotechnology

Biotechnology in industry

Status: The questionnaire is currently in the field. Results from this survey are expected in fall 2000.

Biotechnology R&D in Canadian Industries for 1997

Status: A service bulletin was released in June 2000.

Federal S&T Expenditures

Status: A paper will be released in early fall.

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

Connectedness

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

Telecommunications

Annual survey of telecommunications service providers

Status: The 1999 annual survey is currently in the field being collected.

Quarterly survey of telecommunications service providers

Status: First quarter statistics are due for release in early October. The 2000 quarterly survey will be introducing the option of electronic reporting for our respondents this quarter.

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

Broadcasting

Annual surveys of cable, radio and television

Released: 1999 data for private radio and private television. See publications 56-001-XIB, vol. 30, no.2 and no.3.

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

Household Internet Use

Status: Research papers from the 1999 survey will be released shortly.

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

Business E-Commerce

Annual survey of information and communication technologies and electronic commerce, 1999

Status: Data from this survey were released on August 10, 2000. Please see "The Daily" on Statistics Canada website (www.statcan.ca) for details.

Contact: Cathy Bakker (613) 951-2929
Cathy.Bakker@statcan.ca