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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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As of June, 2003 there were:

- 9 publications for sale
- 9 free publications
- 12 research papers,
- 88 working papers, and
- 27 questionnaires.

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	use with caution
F	too unreliable to be published

Technology and performance in Canadian food processing

The relationship between the use of advanced manufacturing technology and firm performance, as measured by growth in labour productivity and growth in market share during the 1990s, is the subject of this recently released study. Results indicate that a high-technology orientation is closely associated with success.

Food processing: a mature industry

Food processing is one of the largest manufacturing industries in Canada, consisting of more than 3,000 establishments. Employing close to 230,000 people in 1998, it boasted a gross domestic product of $15 billion that same year. The food processing industry is a mature industry, typified by modest-sized plants and moderate growth over the past couple of decades. Its links to the global economy, whether measured by trade or foreign investment, are below the manufacturing average. It may appear that the food-processing industry has lagged other industries in introducing automation. Indeed, many of the processes in this industry are so complex that they are regarded as more of an art than a science. Despite this, new products and processes are constantly being developed and introduced in the food-processing industry.

Change taking place–half of market share shifts

There is considerable change taking place, at the establishment level, within the Canadian manufacturing sector as some plants wrest market share away from others. The same is true for the food-processing industry. Market share changes hands as some plants grow, while others decline. Between 1988 and 1997, almost half of market share had been transferred, shifting from losers to gainers. Use of advanced technology is thought to contribute to this process.

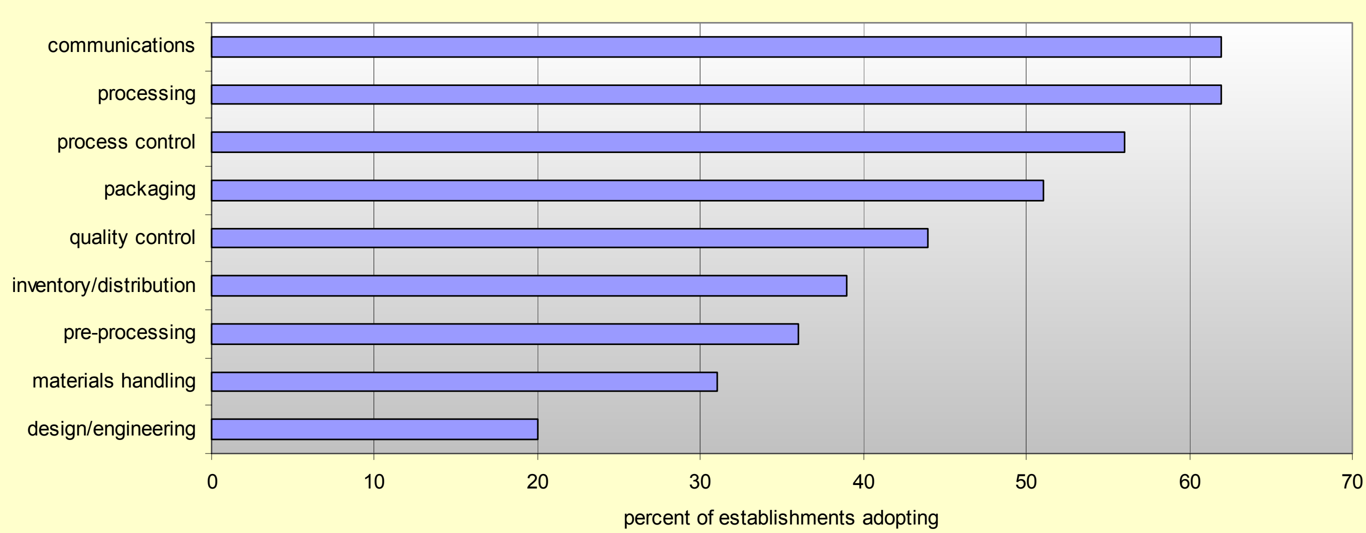
Adoption of advanced technology is expected to lead to superior firm performance. Until now, the data to investigate this presumption has largely been unavailable. This study uses a new set of data to address this issue. Two measures of firm performance are used in this study—productivity growth and market share growth.

Technology use and adoption rates

By the end of the 90s, nine-out-of-ten food-processing establishments adopted at least one of the sixty advanced technologies identified on the 1998 Survey of Advanced Technology in the Canadian Food Processing Industry. Seven percent used 20 or more. Adoption is highest for local area networks, programmable logic controllers, and the use of advanced materials for packaging. At least one third of establishments had adopted these technologies by the late 90s.

In terms of broad technology categories, adoption rates are greatest for network communications and processing technologies, with 62% of food-processing plants adopting at least one technology from each of these two areas (Figure 1). Communications technologies include local and wide area networks, while processing includes the likes of advanced filter technologies, thermal preservation techniques, and the use of bio-ingredients. Process control and packaging are next, both with adoption rates of more

Figure 1. Advanced technology use in Canadian food processing



Source: Statistics Canada, *1998 Survey of Advanced Technology in the Canadian Food Processing Industry.*

than fifty percent. Programmable logic controllers and computerized process control were the most widely-used process control technologies, while the use of multi-layer materials and laminates were the most popular advanced packaging technologies.[1]

Adoption rates vary across plants. Large establishments are not only more likely to adopt advanced technology, they are also more likely to adopt greater numbers of them. Size differences are largest for communications, process control, and design and engineering technologies. Nationality also matters, as foreign-controlled plants are more likely to adopt, even after controlling for their larger plant size.

Use of ICTs associated with higher productivity growth

Earlier studies[2], conducted in a number of different countries, find evidence of a positive link between the use of advanced technology and enhanced firm performance. There is a strong presumption that a similar relationship also exists for the food-processing industry. Indeed, the analysis revealed that plants that adopted greater numbers of advanced technologies enjoyed higher productivity growth. Certain types of technology were found to have a greater impact on growth than others. Adoption of information and communication technologies (ICTs), such as local and wide area networks and inter-company computer networks, are positively associated with higher productivity growth throughout the 1990s. Transfer of information both within and between organizations is closely associated with productivity growth. Adoption of advanced process control and advanced packaging technologies are also linked to greater productivity growth.

Productivity growth and market share growth strongly linked

Adoption of advanced technology and market share growth are found to be related. Yet the predominant story here is the strong relationship that exists between productivity growth and market share growth. Productivity growth and market share growth are highly related. This suggests that growth in market share is significantly related to growth in productivity, which, in turn is significantly related to the adoption of advanced technology. Plants that adopted advanced technology by the end of the 1990s were more likely to have enjoyed higher productivity and, as a result, gained in market share throughout the decade.

Other characteristics also have impact

In addition to technology use, several other characteristics were found to be related to higher productivity growth. Consistent with the literature, growth in capital intensity has a large and significant effect on productivity growth. Implementation of an aggressive human resource strategy, one that values continuous improvement of the workforce, through training and recruitment, is also associated with greater productivity growth.

David Sabourin and John Baldwin, Micro-Economic Analysis Division, Statistics Canada.

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This article is derived from the paper Impact of Advanced Technology Use on Firm Performance in the Canadian Food Processing Sector, *published in the Economic Analysis Series (Cat. no. 11F0027). The paper is available on the Statistics Canada Web site (www.statcan.ca) for free. Papers in the series are distributed to Statistics Canada Regional Offices and provincial statistical focal points.*

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[1] The nine functional areas covered in the *1998 Survey of Advanced Technology in the Canadian Food Processing Industry* are processing, process control, quality control, inventory and distribution, information and communications systems, materials preparation and handling, preprocessing, packaging, and design engineering. Within each of these areas were questions on the use of up to fourteen specific individual technologies.

[2] These findings, based on Canadian empirical evidence, are confirmed by research that covers the experience of other countries. Stoneman and Kwon (1996), Rischel and Burns (1997), Ten Raa and Wolff (1999), Van Meijl (1995), and McGuckin et al. (1998) find a positive relationship between advanced technology use and superior firm performance.

A discussion of the emerging nanotechnology

Nanotechnology is an emerging technology. Has it reached the point that warrants the development of a comprehensive statistical measurement program? If so, what indicators should be used to measure nanotechnology? There is precedence for using developed methods and techniques to address the questions who, what, where, why. Statistics Canada's experience may be invaluable in the development of a nanotechnology statistical program.

What is nanotechnology?

Nanotechnology is defined by the National Research Council (NRC) as "manufacturing at the molecular level—building things from molecular or nano-scale components. A nanometre is one billionth of a metre (3-4 atoms wide). Nanotechnology proposes the construction of novel nano-scale devices possessing extraordinary properties. Through the development of such instruments and techniques it is becoming possible to study and manipulate individual atoms". It is important to note that new behavior at the nanoscale is not necessarily predictable from that observed at large size scales. The most important changes in behavior are caused not by the size reduction, but by the characteristics intrinsic to, or becoming predominant at the nanoscale.

Nanotechnologies are transforming techniques and processes that are not restricted to one sector but a set that spreads across and throughout the economy. The NRC characterizes nanotechnology as "convergence within convergence". In the United States, the National Science Foundation (NSF) identifies nanotechnology as a cornerstone of growth and innovation along side biotechnologies and information technologies, each relying on the other.

Nanotechnology is a cross-sector phenomenon and its potential impacts could be pervasive. Nanotechnologies can be thought of as a whole but as we examine it, the discovery is made that nanotechnologies are found in the areas as diverse as biotechnology and health, agriculture, electronics and computer technology, environment and energy, optics, and in materials and manufacturing. A challenge to measurement of nanotechnology activities lies in this diversity. As nanotechnologies shift from the research laboratories to the commercial front, its impact on economic and social fronts may become more significant.

Nanotechnology: large enough to measure?

Nanotechnology is an emerging set of technologies that may in the very near future warrant a focused attempt at statistical measurement. The question is whether nanotechnology has reached the stage that warrants a comprehensive statistical program or is a continued 'watchful eye' sufficient attention? Any program on nanotechnology will face challenges - some of which are addressed in this article. And there are potential solutions at hand.

Indicators of funding the development of nanotechnology

Currently in Canada there is a major spending initiative of $120 million over 5 years sponsored by the National Institute of Nanotechnology, a partnership between the University of Alberta, the Alberta government ($60 million) and the National Research Council ($60 million). Nanotechnology associations have been formed and interest in the subject is emerging with increasing frequency in the media and general public discussion.

The National Nanotechnology Initiative (NNI), the U.S. Federal government's investment in nanotechnology, is supported by $US604 million in the fiscal year 2002 with plans to spend $US710 million in FY2003. The Department of Foreign Affairs and International Trade reports that in Japan in 2002, 80 billion yen are allocated for R&D in nanotechnology, an amount similar to spending in the USA.

The European Commission's Third European Report on Science & Technology Indicators – 2003 reported that in 2000 in the EU-15 nanotechnology received approximately $290 million (184 million euros[1]) in government support, in the U.S. this figure was $425 million (270 million euros) and in Japan the figure was $275 million (175 million euros). This report states "…nanotechnology is an emerging technology, with great progress being made in science rather than specific applications" (p403). The report highlights a series of indicators, including patents and publications from a variety of sources, to measure nanotechnology performance among European nations and other active nanotechnology nations. It reports Canada at number 11 in nanotechnology publications during the period of 1997-1999, and in the 7th spot in nanotechnology patents with the European Patent Office and Patent Cooperation Treaty from 1991-1999.

These indicators include increased spending and focus on nanotechnology research indicating a growing potential for the need of a systematic development of comparable indicators of nanotechnology. Nanotechnology is in the early stages with very limited commercialization taking place. However, if the excitement surrounding nanotechnology is even partially correct, economic impacts could occur in the near future.

Approaching measurement of nanotechnology: using lessons learned

Even a brief search for a definition of nanotechnology uncovers many competing definitions making one of the first challenges defining precisely – "what is nanotechnology?". The challenge of an exact definition of nanotechnology is complicated in that the boundaries surrounding nanotechnology are not clear as nanotechnology cuts across many different sectors of the economy. For example, where does nanotechnology end and information technologies and biotechnologies begin? Beyond the interest in the economic impact of nanotechnology are related activities such as regulation, education and training, and government expenditures and activities, which need to be addressed.

In order to consider the numerous questions and issues, the guidelines provided in the Science, Innovation, and Electronic

[1] Conversion rate 1.57 (April 22, 2003 Statistics Canada rate) Used for comparative purposes.

Examples of nanotechnology are carbon nanotubes—long, thin cylinders of carbon that are unique for their size, shape, and physical properties. They can be thought of as a sheet of graphite rolled into a cylinder. Graphite is formed from carbon atoms arranged in a honeycomb pattern. These honeycomb layers are stacked one above the other. A single sheet of graphite is very stable, strong and flexible. Since a single sheet is so stable by itself, it binds only weakly to the neighbouring sheets. This explains why graphite is used in pencils: tiny flakes of graphite are left on the paper because although the individual flakes are very strong and flexible, the flakes slide relatively easy. In carbon fibers, the individual layers of graphite are much larger and form a long, thin winding spiral pattern. These fibers are joined with an epoxy, forming an extremely strong, light and expensive composite used in aircraft, tennis rackets, racing bicycles and racecar components.

However, there is another way of arranging the graphite sheets, which is even stronger. The honeycomb pattern of the graphite is wrapped back on top of itself and joining the edges, forming a tube of graphite, a carbon nanotube. These nanotubes are the strongest fibers known. A single nanotube is about 10 to 100 times stronger than steel per unit weight. Not only are carbon nanotubes extremely strong, but they possess interesting electrical properties. A single graphite sheet is a semi-metal, which means that it has properties intermediate between semiconductors (like the silicon in computer chips, where electrons have restricted motion) and metals (like the copper used in wires, where electrons can move freely). Nanotubes have a very broad range of electronic, thermal, and structural properties that change depending on the different type of nanotubes defined by its diameter, its length, and/or its twist.

For additional examples of nanotechnologies see the National Research Council website at: http://www.nrc-cnrc.gc.ca/nanotech/home_e.html.

Information Division's (SIEID) ***Activities and Impacts: A framework for a statistical information system***[2] can be used in conjunction with the lessons learned in recent Statistics Canada surveys (Biotechnology use and development surveys). The framework addresses a series of who, what and where questions[3], which take the form of:

What is nanotechnology? Nanotechnology is a catch all term of activities and techniques that cuts across sectors and this can be extended further to addressing the question: What is a nanotechnology firm?

Who are the actors in nanotechnology? The usual suspects of academia, business and government will be named but the specifics of these will need to be identified along with their respective roles and contributions.

Where is nanotechnology? This not only refers to physical location but to the sector location, where in the economy is nanotechnology. Nanotechnology cuts across sectors and activities.

Why use nanotechnology? What are the results of using nanotechnology? Issues such as reasons for adopting nanotechnologies and the benefits that resulted from adopting and using nanotechnology can be addressed.

How many resources have been committed to nanotechnology? The expenditures both monetary and human can be explored.

How connected? Questions can be asked on how firms link together using as an example, strategic alliances.

Based on experience, development of a statistical program on nanotechnology benefits from the meaningful engagement of stakeholders, the use of this framework, and integrating the methodologies and techniques developed and refined in other innovation surveys. An example of lessons learned is the use of a list-based definition. Rather than a statement defining nanotechnology, nanotechnology could be transformed into a list of measurable products and processes, which as an added benefit addresses in part the cross-sector nature of nanotechnology.

Concluding comment

Despite the challenges facing a systematic measurement of nanotechnology, precedent can be found in the approaches in which the challenges can be discussed. Methods and techniques have been developed and refined that addresses—the who, what, where, why and what results, how much, and how connected questions—raised in SIEID's divisional framework. Canada is a leader in development of national biotechnology statistics and in developing international definitions. The list-based definition of biotechnology tentatively adopted by the OECD is based on Canadian designed definitions used successfully in surveys.

Nanotechnology is fast approaching the stage where a watchful eye may not be enough and additional attention is required. Statistics Canada's experience will be invaluable to the development of a nanotechnology statistical program.

The author of this article encourages readers to respond with their thoughts and comments on addressing the emerging nanotechnology.

Chuck McNiven, SIEID, Statistics Canada.

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[2] For detailed information the reader is referred to the divisional framework document *Science and Technology Activities and Impacts: A framework for a statistical information system*, Statistics Canada, Ottawa , Catalogue no. 88-522-XIE (1998)

[3] See Rose (2000) for a comprehensive discussion of the development of biotechnology statistical program. Rose's work serves as the model for this section.

Employment in the computer and telecommunications industries

Information and communications technologies (ICTs) represent an important aspect of today's society, as they have widely penetrated the workplace and home. A recent study completed by Statistics Canada compared the characteristics of employment in the industries of the ICT sector to employment in the rest of the economy. Computer and telecommunications (CT) industries, although a small group, distinguished themselves with unsurpassed employment growth accounting for 3.9% of total economy employment.

Information and communications technologies (ICTs) have grown over the last decade, as has the production of both ICT goods and services. Analysis based on key variables, such as Gross Domestic Product (GDP), employment, revenues, international trade, and research and development (R&D) found that the ICT sector registered exceptionally high growth—particularly between 1993 and 1999—far surpassing that of the Canadian economy in general. The strong growth of the sector indicates its increasingly important role in the Canadian economy.

Employment in ICT industries

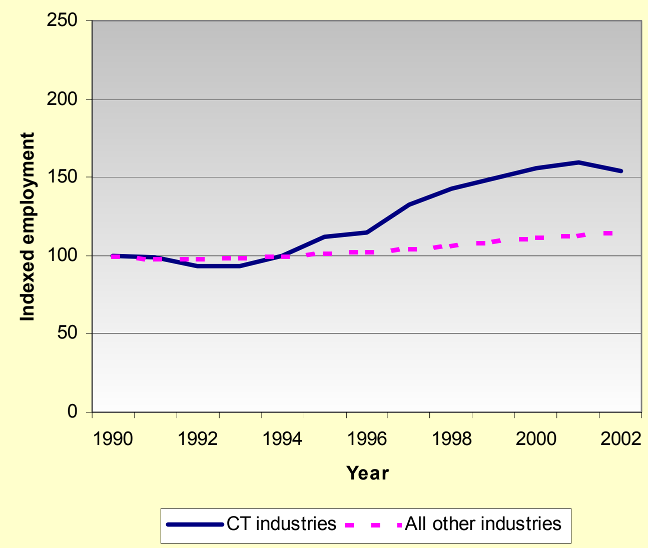
In 2002, the ICT sector contributed $58.7 billion to Canada's GDP, accounting for 7.1% of business sector GDP. The grouping of CT industries examined represents a sizeable sub-set of all industries that comprise the ICT sector. At its peak, in 2002, employment in CT industries accounted for 3.9% of total economy employment.

Employment levels fluctuated in the 1990s, as a decline during the recessionary period was followed by a strong recovery. The CT industries were more severely affected by this decrease at the beginning of the decade, and were slower to recover. Employment growth in both the CT industries and the rest of the economy began in 1993, but 1990 employment levels were not reached until 1995 for the CT industries, while the industry group representing the rest of the economy recovered one year earlier. Employment in the CT industries peaked in 2001, while growth in all other industries continued into 2002 (Chart 1).

In 1990, the group of CT industries analyzed had 359 thousand employees, compared with 12.7 million in the rest of the economy. By 2002, these numbers had grown to 596 thousand and 14.8 million, respectively.

As employment levels began to recover, CT industries registered phenomenal growth, greatly surpassing growth in all other industries. This continued until the end of the decade. Over the course of the 1990-2002 reference period, CT industry employment increased by 66.0%–four times that of the rest of the economy (16.4%). Employment was growing at an average annual rate of 4.3% compared with 1.3% for all other industries. Growth in CT industry employment slowed down in 2000 and 2001, though employment still increased in both industry groups. In 2002 however, there was a marked decrease in CT industry employment, while employment for all other industries accelerated slightly above their 2000 and 2001 rates.

Chart 1. The CT industries were affected more by recession, and were slower to recover, however they experienced much higher growth once recovery began.



CT industries are male-dominated

Most CT industries employ a greater proportion of male workers than female. This may be explained by the fact that there are no health occupations in the CT industries—one of the occupations in which women traditionally work. However, there are some exceptions to the male-dominated CT industries, such as data processing services, where three-quarters of the employees were female in 2000, and women comprised at least half of its workforce for much of the reference period.

Contrary to the growth in all other industries, employment growth for women in CT industries was not as significant as it was for men. Between 1990 and 2002, employment growth in all other industries was nearly twice as high for women than for

Table 1. Employment growth in CT industries, 1990-2002

	Male	Female	Total
	% change 1990 to 2002		
All employees in all other industries	11.6	22.5	16.4
All employees in CT industries	74.9	50.8	66.0

Chart 2. Employment in CT industries, 1990-2002

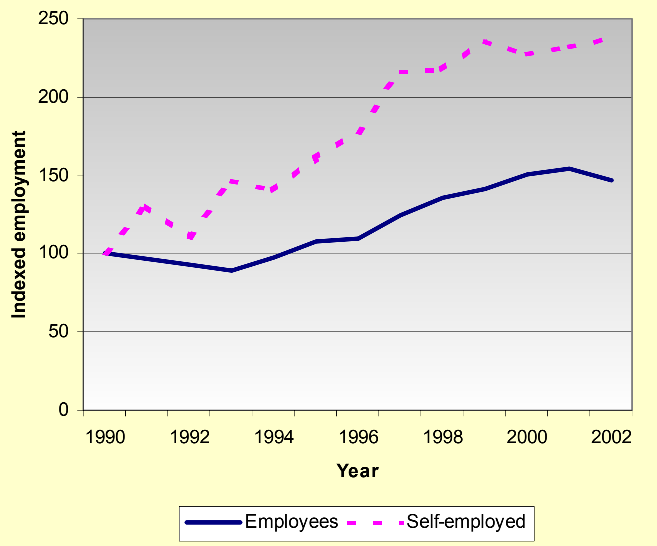
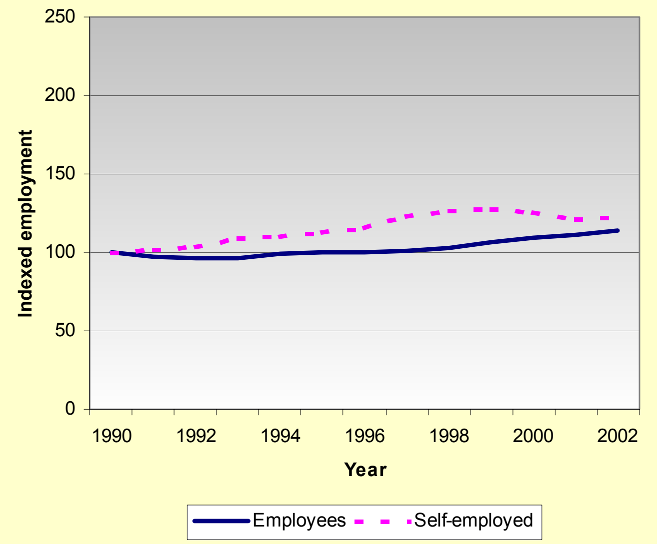


Chart 3. Employment in all other industries, 1990-2002



men. In CT industries, though, employment growth for women was only two-thirds that of men's—but still substantial at nearly 51% (Table 1).

Workers in CT industries more educated

The proportion of university graduates in the CT industries is greater than in the rest of the economy, for all years examined. This is true for both males and females. University graduates accounted for 22.8% of the CT industry workforce in 1990 and 37.8% in 2002. In all other industries, these proportions ranged from 14.2% in 1990 to 19.6% in 2002. Thus, in 2002, the proportion of university graduates in all other industries still did not reach the proportion found in the CT industries twelve years earlier.

CT workers are younger

The average age of workers increased steadily over the 1990-2002 period, indicative of an ageing workforce. In the all other industries group, workers were on average two years older in 2002 (37.9) than in 1990 (35.6). The average age of workers in CT industries, though, remained relatively stable, at least until 2000. As a result, from 1994 to 2000, an increasing gap in the average age between the two industry groups has emerged, with CT workers always being younger. Workers in CT industries are ageing, but still younger than the rest of the economy.

CT self-employment and its growth highly concentrated

The proportion of self-employment in CT industries is lower than in the rest of the economy, but the gap has been closing. At its peak, in 1998, the proportion of self-employment in all other industries was 17.3% of total employment. For the CT industry group, this proportion peaked at 14.6% one year later–nearly doubling in relative importance from its share of 7.4% in 1990. As overall employment growth slowed, the proportion of self-employment declined in both groups. This trend was reversed in 2002 for the CT industry group, where self-employment reached a high of 84 thousand (14.1% of total employment). This increase in self-employment may have been prompted by job loss in the CT industry group that same year.

Self-employment in both CT and all other industries grew at a much greater rate than that of employees (Charts 2 and 3). Between 1990 and 2002, growth in self-employment for CT industries (216.9%) was nearly four times greater than growth in employees (53.9%), while for all other industries it was only one-and-a-half times greater (24.5% vs. 15.1%). This accounted for the closing gap in self-employment between CT and all other industries. While growth in employees was steady in CT industries from 1993 to 2002, it remained fairly flat in all other industries from 1994 to 1997, with growth only occurring in the later part of the decade–when self-employment began to decrease.

Part-time jobs not prominent in CT industries

The differences between CT industries and the rest of the economy are remarkable with respect to part-time employment. While the proportion of part-time jobs is quite high in all other industries as a group (about 20%), the vast majority of CT jobs are full-time (the proportion of part-time jobs is 5.4% at its highest, in 1996).

Summary

As evident by its contribution of $58.3 billion to Canada's GDP and accounting for more than 7% of business sector GDP, the ICT sector is playing an increasingly greater role in the Canadian economy. The computer and telecommunications sector represents a significant sub-set of the ICT sector and accounts for 3.9% of total economy employment.

The CT sector employs more men than women and employees are generally younger, have a greater education and work full-time rather than in part-time positions.

Chantal Vaillancourt, SIEID, Statistics Canada.

This article is based upon a paper from Statistics Canada's Connectedness Series, Volume 9, A Profile of Employment in Computer and Telecommunications Industries*, authored by C. Vaillancourt, Catalogue No. 56F0004MIE, No. 9, released in March 2003.*

Large public and private sector organizations and their use of ICTs

What do government and business have in common? A quick look at the results from Survey of Electronic Commerce and Technology seems to show that there are not many common characteristics. But dig a bit deeper, and we start to see the similarities between larger public and private organizations and the degrees to which they adopt ICTs.

Between the sectors

At the sector level (private and public), units of all sizes are grouped together. While this grouping is useful to get a general idea of how the sector is performing overall, a comparison between the two has its limits as the two sectors are composed of different proportions of the different sized organizations. In Table 1, when comparing "all organizations", it appears as though public organizations are much more likely to adopt most of the ICTs, especially Intranets, extranets and Web sites.

While the private sector is composed of businesses of all sizes, the public sector has fewer small units. A recent paper by Charles, Ivis, and Leduc (2002) points out the noticeable difference in adoption rates between small and large organizations. Smaller organizations, for example, may have less need for Intranets, extranets and Web sites.

A fairer comparison

When we compare large businesses (over 500 employees) with the large private sector organizations (also over 500 employees), most of the differences disappear. In Table 1, under "Large organizations", the main difference is that large public sector organizations are much less likely to use wireless communication (mobile phones, wireless LANs, wireless data devices (PDA), wireless laptops and pagers) than large businesses. This may be the influence of different working styles (working in the office or out of the office), the newness of the technologies and differing approaches to secure communications.

Another remaining point of difference is that large public organizations are more likely to have a Web site.

Differing Motives

Private and public organizations have different motives for providing on-line content on the Internet. The private sector has a competitive or profit motive driving businesses to put up Web sites. Due to the nature of some government agencies and the type of work or service they provide, not all deparments have a product or service that can be sold on-line. In general, governments are interested in providing access to information and sharing between departments. This is exemplified by the federal government's Government On-Line (GOL) initiative. The intent of the program is to provide more uniform accessibility to Canadians and international visitors, better service times, trust in on-line transactions, a greater choice in service delivery mediums and accessibility of both official languages.

Large public organizations and large businesses are as likely to:

- Have personal computers, workstations or terminals,
- Use e-mail,
- Have access to the Internet,
- Make purchases over the Internet, and
- Use network security technologies (such as firewalls and anti-virus software).

Table 1. Information and communications technologies used

	All organizations		Large organizations	
	Private sector	Public Sector	Private Sector	Public Sector
Technology	% using technology			
Personal computers, workstations or terminals	85.5	99.9	99.9	100.0
E-mail (electronic mail)	71.2	99.6	99.9	100.0
Wireless communication	57.8	70.8	88.6	78.8
Internet access	75.7	99.6	99.9	99.8
Intranet	14.8	76.8	76.8	81.2
Extranet	5.3	37.7	44.1	48.6
Network or information security technology	55.5	95.0	96.8	97.6
Web site	31.5	87.9	87.1	94.8
Selling over Internet	7.5	14.2	23.3	17.4
Purchasing over Internet	31.7	65.2	70.3	70.0

Source: Statistics Canada, 2002 Survey of electronic commerce and technology, Science, Innovation and Electronic Information Division. The survey covered about 21,000 enterprises.

Some small differences remain:

- Public organizations are slightly more likely to use Intranet and Extranet sites than large firms; and
- Large businesses are more likely to sell over the Internet.

Given that most businesses have a good or service to sell, a higher proportion of large businesses sell on-line than large public organizations. While some departments will have items for sale on their Web sites, governments are more likely to focus on providing forms, documents and other information to facilitate compliance, information dissemination and the reduction of burden on businesses and individuals.

Large businesses and large public sector organizations are virtually identical in terms of purchasing on-line, with private firms ahead slightly for the first time in three years.

Conclusions

Once the size factor is taken into account the ICT use of large businesses and large public organizations are very similar. The main differences are in terms of the use of wireless communication technologies, presence of Web sites, Intranets, extranets and selling over the Internet. Analysis of these rates over time could perhaps help to ascertain whether these differences and similarities are due to differing rates of adoption or to structural differences between the sectors.

Bryan Van Tol and Geoffrey Li, Science, Innovation and Electronic Information Division, Statistics Canada.

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Government on-line: www.gol-ged.gc.ca.

Sandra Charles, Matthew Ivis, and André Leduc, 2002, *Embracing e-business: Does size matter?* Statistics Canada, Connectedness Series, Cat. no. 56F0004MIE, No. 6, Ottawa, Canada.

Data related to this article were originally released in Statistics Canada's ***The Daily****, April 2, 2003.*

Why are Canadian biotech firms having problems raising financing capital?

Canadian biotech firms raised $980 million in financing capital in 2001, a sharp drop from the $2.1 billion raised in 1999. Overall, 61% of firms that attempted to raise capital either failed or did not reach their targets. Why are biotech firms encountering difficulties in raising financing capital?

The financial facts

In 2001, Canadian biotech firms raised $980 million in financing capital. This amounts to more than twice the $467 million they raised in 1997. However, it is a sharp drop from the $2.1 billion raised in 1999. Overall in 2001, 114 firms out of 188 (61%) that attempted to raise capital, either failed or did not reach their targets[1].

Risk and intangible assets

What factor contributes to why biotech firms have difficulties in raising financing capital? The survival of any biotech firm is based upon the requirement of profit and the sustainability of a competitive edge. This is directly dependent on a firm's strengths: (i) a healthy product portfolio and (ii) specific expertise and skills of the managers. Only 11% of the refusals or credit limit were based on these two critical factors (Table 1).

Surprisingly, these factors are given very little weight in assessing a biotech firm's creditworthiness. Since only 11% of the refusals were based on limitations of the firm's product portfolio or management skills, this indicates that biotech firms have been able to show investors their actual worth. Two reasons may explain the investor's reluctance to lend the necessary funds to apparently viable firms. First, investors may have correctly assessed market conditions and the level of development of product but are reluctant to take the risk with developmental projects.

Secondly, many biotech firms do not earn any revenues, a key performance and creditworthiness indicator for most investors. In addition, most of their assets are in the form of intellectual property rights and other intangible assets that are difficult for investors to assess a value.

These contentions are also supported by findings indicating that biotech firms, in general, are having difficulties securing capital (Traoré, 2003).

Reasons for capital refusal or limitation

As evident from the data presented in Table 1, the limited success of biotechnology firms in acquiring capital financing included the following reasons:

[1] Between 1997 and 1999, less than 30% of the increased observed is attributed to changes in survey methodology.

Table 1: Reasons for which biotech firms' requests for capital were refused or limited, 2001

Reasons	Number of firms whose requests were refused or limited[1]	Number of small firms whose requests were refused or limited
Total	114 (100)	100 (88)
Capital not available due to market conditions	78 (68)	68 (87)
Further product development or proof of concept required	43 (38)	37 (86)
Biotechnology products/processes not sufficiently developed	42 (37)	37 (88)
Lender does not fund development projects	28 (25)	25 (89)
Other reasons[2]	26 (23)	24 (92)
Biotechnology product line or portfolio limited in scope	13 (11)	13 (100)
Insufficient specific management skills/expertise	12 (11)	12 (100)

Source: Statistics Canada, BUDS-2001.

[1] Figures in Column 1 do not add up to 114 as any given firm may be denied capital for multiple reasons. The 114 firms include 60 firms that did not reach their financing target and 54 firms that were outright refused financing.

[2] Other reasons for which requests for capital were refused or limited included GMO being an issue of concern, lack of strategic partners, lack of lender's expertise to assess biotechnology, lack of benchmark against which to assess success of a new biotechnology product market.

- in 78 cases, funds were rejected or limited because of market conditions,
- in 43 cases, lenders needed further product development or proof of concept,
- in 42 cases, biotechnology product/process was deemed insufficiently developed to warrant financing,
- in 28 cases, financing was denied because lenders were not funding development projects,
- in 26 cases, issues related to Genetically Modified Organisms, (GMOs) were a concern, lack of strategic partners, lender's lack of expertise to assess biotechnology, lack of benchmark against which to assess new biotech market success,
- 13 cases were denied or limited because the firm had a limited biotechnology product line or portfolio, and
- 12 cases quoted insufficient specific management skills/expertise as the reason for denying financing.

Small biotech firms

Small firms experienced lower success rates in obtaining capital funding. Out of 156 attempts by small firms at securing funding, 56 or 36% succeeded. For medium and large firms, the success rate was 57% and 67% respectively. Funding was denied or limited for various reasons with three main reasons being most prominent. These were funding denied because of "market conditions", 68 (87%) of the 78 firms denied, were small firms. For the requirement of "further product development or proof of concept", 37 out of 43 refusals were small firms. Out of 42 firms that were refused because their "product/process were not sufficiently developed", 37 were small.

All the firms that were denied funding or whose funding request was limited because of limited biotechnology product portfolio and insufficient specific management skills/expertise were small firms. These results are in line with findings by McNiven, Raoub, and Traoré (2003) and by Niosi (2000) supporting biotechnology firms' claims that they have difficulty attracting capital to finance their activities.

Identifying difficulties

Easy access to capital is an essential enabler of rapid growth in biotechnology (Niosi, 2000). The data presented in this article indicate that access to capital is limited by investors' reluctance to take risks with developmental projects and by their difficulty in assessing intangible assets.

Namatié Traoré, SIEID, Statistics Canada.

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Niosi, Jorge, 2000, *Explaining Rapid Growth in Canadian Biotechnology Firms*, SIEID, Research Paper No.8. Cat. No. 88F0017MIE, Ottawa.

New economy indicators

In this issue, we have compiled some of the most important statistics on the new economy. The indicators will be updated, as required, in subsequent issues. For further information on concepts and definitions, please contact the editor.

	Units	1997	1998	1999	2000	2001	2002
General economy and population[1]							
GDP	$ millions	882,733	914,973	980,524	1,064,995	1,092,246	1,122,712
GDP implicit price index	1997=100	100.0	99.6	100.9	105.2	106.3	..
Population	thousands	29,987	30,248	30,509	30,791	31,111	31,414
Gross domestic expenditures on R&D (GERD)[2]	$ millions	14,639	16,082	17,465	19,585	20,828	20,744
"Real" GERD	$ millions 1997	14,639	16,147	17,309	18,617	19,594	..
GERD/GDP	ratio	1.66	1.76	1.78	1.84	1.91	1.85
"Real" GERD/Capita	$ 1997	488.2	533.8	567.3	604.6	629.8	..
GERD funding by sector							
Federal government	% of GERD	19.2	17.6	18.4	18.2	18.4	19.1
Provincial governments	% of GERD	4.5	4.0	4.4	4.5	4.5	4.9
Business enterprise	% of GERD	48.1	45.7	44.3	42.5	41.9	40.0
Higher education	% of GERD	13.5	14.5	15.2	14.5	15.0	16.5
Private non-profit	% of GERD	2.5	2.3	2.2	2.3	2.3	2.6
Foreign	% of GERD	12.3	15.9	15.9	18.1	17.8	16.9
GERD performance by sector							
Federal government	% of GERD	11.7	10.8	10.6	10.6	10.6	10.7
Provincial governments	% of GERD	1.5	1.3	1.3	1.3	1.2	1.3
Business enterprise	% of GERD	59.7	60.2	58.6	58.5	57.5	54.2
Higher education	% of GERD	26.5	27.2	29.1	29.3	30.3	33.5
Private non-profit	% of GERD	0.6	0.5	0.4	0.3	0.3	0.3
Federal intramural as a % of funding	% of federal	61.1	61.6	57.8	58.5	57.8	56.1
"Real" federal contribution to GERD	$ millions 1997	1,720	1,750	1,842	1,977	2,086	..
Information and communications technologies (ICT)							
ICT sector contribution to GDP - basic prices[3]							
ICT, manufacturing	$ millions	8,228	9,720	13,168	18,062	12,788	10,608
% of total ICT	% of total ICT	25.2	25.8	27.7	31.2	22.3	18.1
ICT, services	$ millions	24,487	28,020	34,340	39,870	44,457	48,063
% of total ICT	% of total ICT	74.8	74.3	72.3	68.9	77.7	81.9
Total ICT	$ millions	32,715	37,734	47,464	57,858	57,222	58,670
Total economy[4]	$ millions	816,081	848,414	892,870	933,713	947,039	977,322
ICT % of total economy	%	4.0	4.4	5.3	6.2	6.0	6.0
Total business sector	$ millions	679,562	710,188	752,197	791,306	801,870	828,842
ICT % of business sector	%	4.8	5.3	6.3	7.3	7.1	7.1
ICT adoption rates (private sector)							
Personal Computer	% of enterprises	..	..	81.9	81.4	83.9	85.5
E-Mail	% of enterprises	..	..	52.6	60.4	66.0	71.2
Internet	% of enterprises	..	..	52.8	63.4	70.8	75.7
Have a website	% of enterprises	..	..	21.7	25.7	28.6	31.5
Use the Internet to purchase goods or services	% of enterprises	..	..	13.8	18.2	22.4	31.7
Use the Internet to sell goods or services	% of enterprises	..	..	10.1	6.4	6.7	7.5
Value of sales over the Internet	$ millions	..	..	4,180	7,246	10,389	13,339

[1] Source: Statistics Canada, 2003, *Canadian Economic Observer*, Cat. no. 11-010-XIB, May 2003, vol.16 no.05, Ottawa, Canada.
[2] Source: Statistics Canada, 2003, *Science Statistics,* Cat. no. 88-001-XIB, various issues, Ottawa, Canada.
[3] Source: Statistics Canada, 2002, *Beyond the information highway: networked Canada (Information and communications technologies (ICT)*, Cat. no. 56-504-XIE, Ottawa, Canada.
[4] The "total economy" is in chained-Fisher methods of deflation and therefore does not match GDP.

	Units	1997	1998	1999	2000	2001	2002
Information and communications technologies (ICT) continued							
ICT adoption rates (public sector)							
Personal Computer	% of enterprises	..	..	100.0	100.0	100.0	99.9
e-mail	% of enterprises	..	..	96.6	99.0	99.7	99.6
Internet	% of enterprises	..	..	95.4	99.2	99.7	99.6
Have a Web site	% of enterprises	..	..	69.2	72.6	86.2	87.9
Use the Internet to purchase goods or services	% of enterprises	..	..	44.2	49.1	54.5	65.2
Use the Internet to sell goods or services	% of enterprises	..	..	14.5	8.6	12.8	14.2
Value of sales over the Internet	$ millions current	..	..	244.6	11.5	354.8	327.2
Teledensity indicators							
Wired access (Voice Grade Equivalent - VGE)	per 100 inhabitants	62.2	63.8	64.9	66.1	65.2	63.4
Wireless access (VGE)	per 100 inhabitants	14.0	18.5	23.7	29.4	34.8	37.6
Total public switched telephone network (PSTN) (VGE)	per 100 inhabitants	76.7	82.3	88.6	95.5	100.0	101.0
Homes with access to cable	thousands	10,422.4	10,564.6	10,725.2	10,896.1	11,107.4	..
Homes with access to Internet by cable	thousands	..	..	..	7,609.7	9,391.4	..
Access indicators							
Total wired access lines (VGE)	thousands	18,659.9	19,293.7	19,806.2	20,347.0	20,335.9	19,962.1
Residential access lines (VGE)	thousands	12,427.4	12,601.5	12,743.9	12,922.0	12,852.3	12,755.8
Business access lines (VGE)	thousands	6,232.6	6,692.2	7,062.4	7,425.0	7,483.6	7,206.3
Analogue mobile subscribers	thousands	450.1	1,406.4	2,592.0	4,444.0	6,950.6	8,943.6
Digital mobile subscribers	thousands	..	3,939.0	4,318.3	4,282.6	3,911.0	2,905.4
Digital cable television subscribers	thousands	..	..	..	390.4	811.7	..
Satellite and MDS subscribers	thousands	..	..	..	967.5	1,609.4	..
High speed Internet by cable subscribers	thousands	..	..	..	786.3	1,387.8	..
Network investment indicators[5]—Capital expenditures							
Wireline public telecommunication networks	$ millions	3,615.6	4,629.1	4,258.7	4,989.9	5,078.7	3,979.5
Wireless public telecommunication networks	$ millions	1,892.3	1,462.6	1,374.1	2,005.7	2,642.4	1,718.3
Cable networks	$ millions	819.1	773.2	1,110.8	1,523.9	2,124.6	..
Satellite and MDS networks	$ millions	7.7	30.6	194.1	158.1	521.2	..
Characteristics of biotechnology innovative firms[6]							
Number of firms	number	282	..	358	..	375	..
Total biotechnology employees	number	9,019	..	7,748	..	11,897	..
Total biotechnology revenues	$ millions	813	..	1,948	..	3,569	..
Expenditures on biotechnology R&D	$ millions	494	..	827	..	1,337	..
Export biotechnology revenues	$ millions	311	..	718	..	763	..
Import biotechnology expenses	$ millions	..	..	234	..	433	..
Intellectual property commercialization[7]							
Federal government							
New patents received	number	..	130	89	..	110	..
Royalties on licenses	$ thousands	..	6,950	11,994	..	16,467	..
Universities							
New patents received	number		143	325		339	
Royalties on licenses	$ thousands		15,600	18,900		44,397	

[5] Figures for 2001 and 2002 are based on Q4 data from the service bulletin *Quarterly Telecommunications Statistics*, Cat. no. 56-001-XIE.

[6] Source: Statistics Canada, 2003, *Features of Canadian biotech innovative firms: results from the Biotechnology Use and Development Survey – 2001*, Science, Innovation and Electronic Information Division Working Paper Series, Cat. no. 88F0006XIE2003005, Ottawa, Canada.

[7] Sources: Statistics Canada, Federal Science Expenditures and Personnel Survey, and Survey of Intellectual Property Commercialization in the Higher Education Sector (various years).

Strategic alliances in biotechnology: characteristics and impact on performance indicators

For many companies, innovation is a key factor in staying successful and keeping their competitive advantage. However, in younger technologies such as biotechnology, few companies have all the resources they need to bring their products to market. Strategic alliances are a means of achieving that objective. This article presents the results of a study presented at Statistics Canada's 2003 Economic Conference that looks at the characteristics of Canadian biotechnology firms that form strategic alliances and measures the impact that such alliances have on their performance indicators. In 1999, small biotechnology firms formed on average fewer alliances than medium-sized and large firms. Biotechnology firms in the human health sector accounted for the biggest share of alliances for that year. In addition, while strategic alliances have a significant positive impact on the performance indicators of biotechnology companies, the effect appears to be stronger when the alliances are with foreign partners.

Introduction

To maintain their innovative capability, biotechnology firms need to have and continually develop knowledge and skills in many technological fields. By creating skills and knowledge spillovers, alliances give firms access to various resources, especially knowledge. Combining that knowledge is a way for firms to create new products and improve their growth and performance. Biotechnology firms' alliance behaviour and relationships vary by sector and size category. For example, although the literature asserts that alliances between small and larger firms are necessary and profitable for both, our results suggest that small companies are less likely to enter into strategic alliances. The aim of this article is to determine, first, whether specific characteristics of biotechnology firms (such as size and sector) are related to strategic alliances and, second, what impact strategic alliances and foreign alliances have on selected performance variables. Since some biotechnology companies often have no revenues, we do not use financial performance variables but rather measures of the firm's innovative capability (number of patents, intensity of biotechnology R&D, and number of products/processes at each stage in the development pipeline) and financing capability.

Characteristics of biotechnology firms that have formed alliances

In 1999, small biotechnology firms[1] accounted for 59% of all strategic alliances (total = 694), followed by large firms (23%). Although, in theory, we would expect small firms to be more likely to form alliances in order to fulfil and complete their various resource (financial or other) needs, in reality, the 1999 data shows that small companies formed on average fewer alliances (2) than medium-sized firms (3) and large firms (5). The large number of alliances formed by small firms is therefore due to the large number of firms in that size category. In 1999, 75% of biotechnology companies were in the "small" category.

An alliance can be a formal or informal arrangement. In informal arrangements, ownership rights and revenue sharing are not always clearly defined. There is also an element of risk and uncertainty about the final product in some types of alliances. For example, for alliances whose purpose is R&D, the final outcome of the research – the product/process in question—is not known in advance. Small companies that partner with larger firms face the problem of asymmetrical information exchange, in which the other partner's behaviour is unpredictable, which can lead to opportunism and free riding[2]. When a small firm takes on a partner, it faces risks and costs that can sometimes outweigh the advantages of the alliance. Among those costs are the risk of losing its independence, of being appropriated by its competitor and of being taken over by a partner, which through the transactions will have an inside view of the quality of the firm's work, its ideas or the products it has developed (Oliver, 1994). Conversely, large companies tend to prefer allying themselves with firms that have already demonstrated their credibility (through patents for example) and innovation capability (by diversifying the products they have in the pipeline). The Biotechnology Use and Development Survey–1999 shows that small companies that formed alliances had, on average, half less patents than medium-sized firms and 9 times less than large firms. Because they are new, small firms constitute a risk and a responsibility for their partners (Singh et al., 1986).

Alliance behaviour varies with firm size and sector. Depending on its size, the firm tends to form alliances with a variety of partners for different purposes. For example, medium-sized companies tend to enter into alliances with all types of partners, whereas large firms are likely to choose non-commercial partners. Large firms form alliances for the purposes of R&D, access to knowledge and technical expertise, and prototype development; alliances with government agencies and universities/hospitals will provide them with access to federal laboratories with highly specialized, state-of-the-art equipment and highly skilled scientific personnel.

Firms in the human health sector are likely to enter into alliances. Because of the complexity of the intellectual property protection process, the regulations and the costs associated with the product

[1] A small firm has fewer than 50 employees, a medium-sized firm between 50 and 149 employees, and a large firm 150 or more employees.

[2] These interpretations are based on previous literature on the subject. *The Biotechnology Use and Development Survey – 1999* doesn't provide data that support them.

approval process, they tend to form alliances in order to share costs and risks and take advantage of the pharmaceutical giants' expertise. In 2001, the human health sector accounted for 67% of the total costs in Canada of taking a primary biotech product/process from the initial development stage to the marketing stage.

Impact on performance indicators

Strategic alliances are a means for biotechnology firms to meet their resource needs (human, technical and financial) and ensure growth and performance. Since some biotechnology companies often have no revenues, the performance variables we use are the number of patents, financing capability, intensity of biotechnology R&D, and number of products/processes at each stage of development.

Strategic alliances and alliances with a foreign partner generally have a significant positive impact on the selected performance variables. Number of patents, R&D investment and number of products/processes at each development stage are factors that contribute to and lay the groundwork for the increased innovation capability required by high-tech firms. The firms need to maintain a consistent innovation capability in order to meet the market's requirements and ensure their survival.

Foreign alliances generally have a greater impact on performance variables than total alliances. *The Biotechnology Use and Development Survey* doesn't provide direct explanations to this result. However, empirical research on this subject shows that high-tech firms often form alliances with foreign partners because they are unable to develop all the critical technological elements they require (Jain, 1987). Through international alliances, they are able to find knowledge outside their geographical boundaries. The data indicates that in 1999, 44% of all foreign alliances were formed with a larger firm. By partnering with larger foreign firms, Canadian companies will be able to import both foreign capital and foreign human resources.

Lara Raoub, SIEID, Statistics Canada.

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What's new?

Recent and upcoming events in connectedness and innovation analysis.

Connectedness

A study on the demand and supply of broadband technology will be released in the Connectedness Series this summer. An update to the information and communications technology (ICT) sector statistics is also underway.

Telecommunications

Annual survey of telecommunications service providers

No updates.

Quarterly survey of telecommunications service providers

The results for the fourth quarter of 2002 are presented in *Telecommunications Statistics: fourth quarter* (56-002-XIE, Vol. 26, No 4), was released in April 2003.

Broadcasting

The results for the 2002 reference year for Television and Radio Industries was presented in *Broadcasting and Telecommunications Services Bulletin* (56-001-XIE, volume 33, No. 1 and 2), released in June 2003.

Household Internet use

No updates.

Business e-commerce

Survey of electronic commerce and technology

The results of the 2002 reference year for the *Survey of Electronic Commerce and Technology* were released in the Statistics Canada Daily on April 2, 2003. Data are now available on CANSIM.

Science and innovation

S&T activities

Research and development in Canada

The service bulletin, *Biotechnology Research and Development (R&D) in Canadian Industry, 2000,* was released in June 2003.

The complete series of Gross domestic expenditures on research and development (GERD) is now available on CANSIM II. The series includes totals of Canada from 1963 to 2002 (data for 2001 and 2002 are preliminary), as well as totals by province, for 1979 to 2000. The table includes the following variables: Geography, funder, performer, and science type. Available on CANSIM: table 358-0001

Federal and provincial S&T

Federal science expenditures

The annual publication, *Federal Scientific Activities, 2002-2003*[e] (Cat. No. 88-204-XIE), was released in May 2003.

The service bulletin, *Biotechnology Scientific Activities in Selected Federal Government Departments and Agencies, 2001-2002,* was released in February 2003.

The service bulletin, *Scientific and Technological (S&T) Activities of Provincial Governments, 1993-94 to 2001-2002*[e], was released in February 2003.

The working paper, *Scientific and Technological Activities of Provincial Governments, 1993-94 to 2001-2002*[e], was released in March 2003.

The working paper, *Provincial distribution of federal expenditures and personnel on science and technology, 1994-1995 to 2000-2001*, was released in April 2003.

The working paper, *Federal government expenditures and personnel in the natural and social sciences, 1993-1994 to 2002-2003*, was released in May 2003.

Higher Education Sector R&D

No updates.

Provincial research organizations

No updates.

Human resources and intellectual property

Federal intellectual property management

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

The 2001-02 survey is in the field. Results are expected in the fall of 2003.

The higher education sector

Intellectual property commercialization in the higher education sector

The major results from the 2001 survey were released in April 2003 and a working paper is being prepared. Consultations regarding the content of the 2003 survey are also underway.

Innovation

Innovation in manufacturing

No updates.

Innovation in services

Questionnaire design and testing is currently underway for the *2002 Survey of Innovation in Selected Service Industries.*

Biotechnology

The working paper *Features of Canadian Biotech Innovative Firms: Results from the Biotechnology Use and Development Survey—2001* (Cat. No. 88F0006XIE2003005) was released in March 2003.

Work on the 2003 version of the *Biotechnology Use & Development Survey* has begun. Consultation with stakeholders will continue throughout the summer, 2003. Those interested in commenting on the content can contact Lara Raoub or Chuck McNiven, SIEID, Statistics Canada.

Knowledge management practices

Recently released: *Knowledge Management in Practice in Canada, 2001 (Cat. No. 88F0006XIE2003007).*

Abstract: Findings are presented from a 2001 Canadian pilot survey on the *Use of knowledge management.* Nine out of ten firms surveyed reported using at least one of 23 knowledge management practices that were studied. This survey, a world first by a statistical agency, measured the extent to which knowledge management practices were used by Canadian businesses in forestry and logging; chemical manufacturing; transportation equipment manufacturing; machinery, equipment and supplies wholesaler-distributors; and management, scientific and technical consulting services. The reasons for, and the results of, using knowledge management practices as well as the practices themselves are examined by firm size and by type of adopter.

Coming soon! **Measuring Knowledge Management in the Business Sector: First Steps**; an Organisation for Economic Co-operation and Development (OECD) and Statistics Canada co-publication. This book will present results from the pilot knowledge management surveys conducted in Canada, Denmark, Germany and France. It will be available for purchase from the OECD in October, 2003.