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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**
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- **Telecommunications and broadcasting**
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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 October 2001, there were:

- 13 fee publications
- 5 free publications
- 13 research papers,
- 51 working papers, and
- 26 questionnaires.

Adapt/adopt: skill shortages and advanced technologies

Over the past decade, use of advanced technology has increased dramatically, particularly in the post recession period of the early nineties. Adoption rates of advanced technologies have doubled in the five-year period 1993 to 1998. Growth has been fastest for network communications technologies—technologies that have been associated with high productivity and rapid growth. With this acceleration in technological growth comes an increase in demand for skilled labour. Concerns over an insufficient supply of skilled labour are being raised: that shortages will occur, that firm performance will be affected and that the ability of firms to compete will be affected. The extent to which these shortages exist in the Canadian manufacturing sector, and their effect on the decision to adopt advanced technologies are examined in this recently released study. The study finds that while many firms reported skill shortages, these problems were no greater for those who failed to adopt any technologies. Rather, shortages emerge as a result of advanced technology use.

Introduction

The need to innovate and compete requires the adoption of new technologies. A highly skilled workforce is required to operate and to develop these new technologies. Whether this increasing need actually poses a problem to firms, however, is a matter of debate. Some feel that shortages pose a real threat to Canadian firms, while others contend that although there may be shortages, firms have the resources to deal with them. The purpose of this paper is twofold: to first determine the extent to which manufacturing establishments experience skill shortages, and second, whether these shortages actually create a problem.

Occupational shortages

Two-thirds of advanced technology-using manufacturing establishments experienced some type of skill shortage in the latter part of the 1990s, according to the results of a recent technology survey, the 1998 *Survey of Advanced Technology in Canadian Manufacturing*. Shortages are greatest for machine operators, industrial engineers and machinists, with about a quarter of plant managers reporting a shortage in each of these areas (Figure 1). Production managers and computer professionals are next, with one-in-five plants indicating a shortage.

In terms of broad occupational categories, shortages are greatest for the professional and skilled trade workers, with roughly 40% of technology users experiencing a shortage in each of these areas. Close behind are technicians and technologists at 37%, with the fewest shortages reported for management (31%).

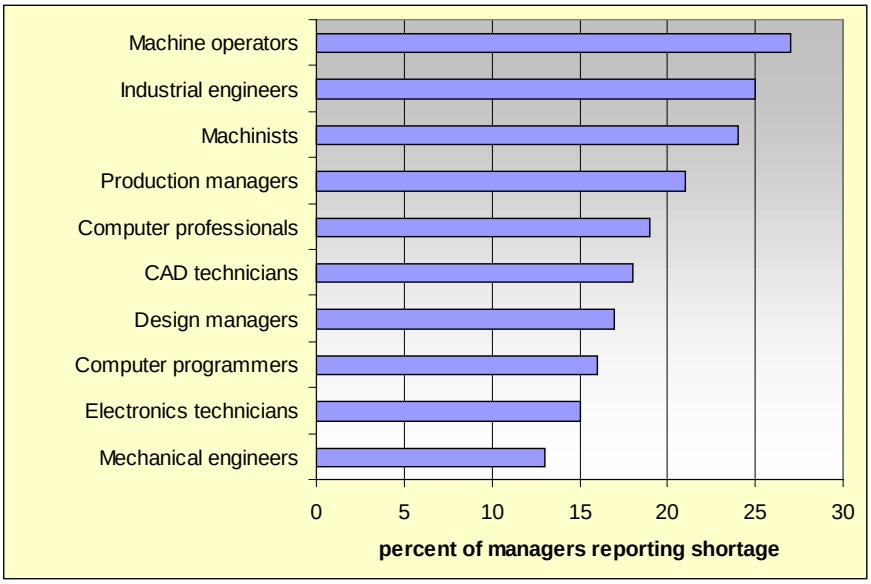
These shortages vary across plants. Large establishments, for example, are more likely to report a shortage than small establishments (Figure 2). Large and medium-sized plants report the greatest shortages for professionals, while small plants claim equal shortages of professionals and skilled tradespeople. Other than foreign-controlled plants reporting a slightly higher level of shortages for professionals, domestic-controlled and foreign-controlled plants report similar shortages.

Skill shortages are also positively related to the adoption of advanced technology. Plants using more advanced technologies are the most likely to report a shortage, particularly when it comes to professionals. Sophisticated technology requires higher skill levels, particularly professional skills, like those possessed by engineers, scientists and computer specialists (Figure 3).

Shortages as impediments to adoption

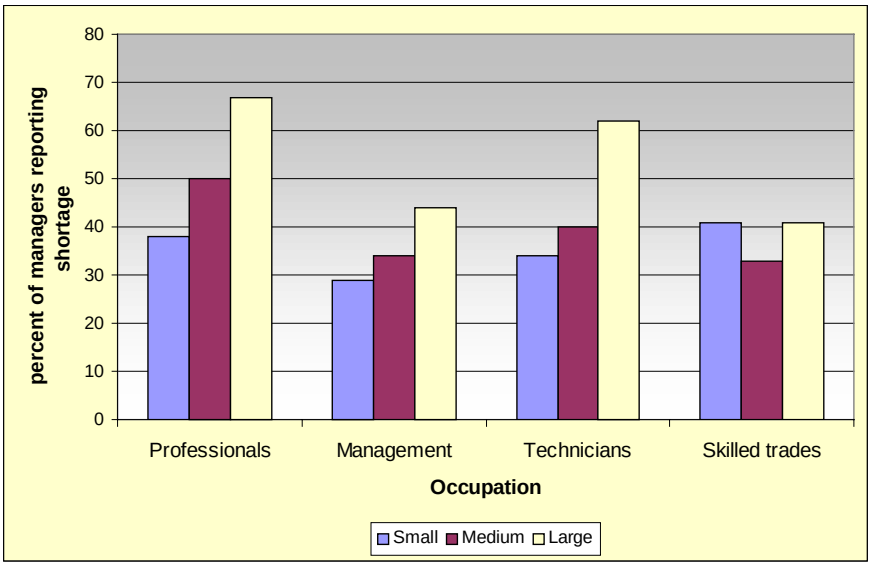
Simply reporting an occupational shortage does not mean it is an actual impediment to technology adoption. The effect of skilled labour shortages on a firm depends on the available labour supply. Firms able to deal with skill shortages, either

Fig. 1: Skilled personnel shortages



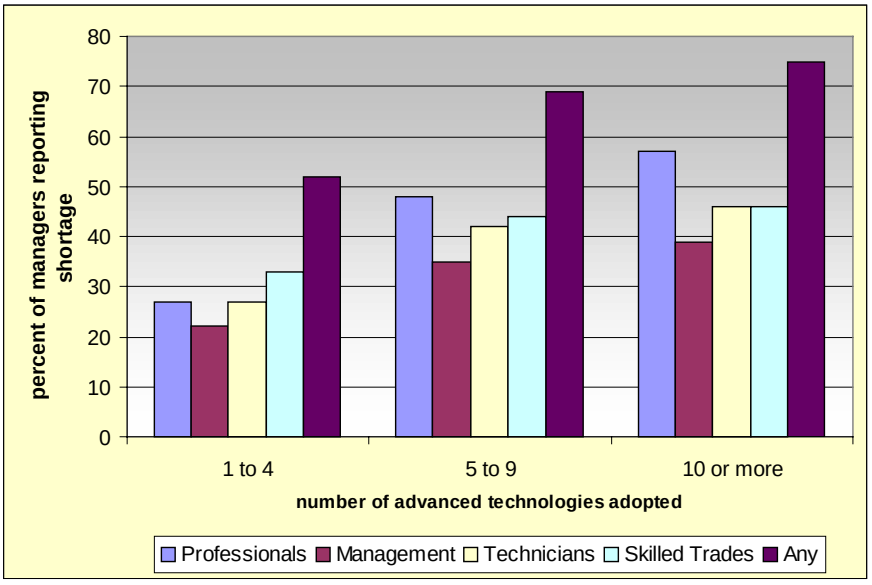
Source: Statistics Canada, 2001, *Skill Shortages and Impediments to Adoption of Manufacturing Technology*, Analytical Studies Branch Research Series, Cat. No. 11F0019MIE.

Fig. 2: Skilled personnel shortages by establishment size



Source: Statistics Canada, 2001, *Skill Shortages and Impediments to Adoption of Manufacturing Technology*, Analytical Studies Branch Research Series, Cat. No. 11F0019MIE.

Figure 3. Skilled personnel shortages by intensity of advanced technology adoption



Source: Statistics Canada, 2001, *Skill Shortages and Impediments to Adoption of Manufacturing Technology*, Analytical Studies Branch Research Series, Cat. No. 11F0019MIE.

through a training program or a hiring program or both, are less likely to consider insufficient supplies of skilled labour to be a serious obstacle to adoption. Being unable to deal with these shortages, though, either through lack of experience or inadequate resources, may pose a serious threat to a firm by increasing its costs through increased wages or increased training costs. This can lead to the erosion of a firm's ability to compete.

Our analysis finds that labour shortages were not the sort of impediment that blocked technology adoption. Indeed, plants for which skill shortages are seen to be an impediment are more likely to adopt advanced technologies and to adopt greater numbers of them. Skill shortages develop as plants adopt new technologies and learn about their skill requirements. Plants for which skill shortages are an issue are also more likely to take corrective action once a shortage is encountered. They are more likely to train, to improve wages and benefits and to actively search for new personnel. This suggests that, although a lack of skilled labour poses a real challenge for many plants, it does not necessarily result in reduced adoption rates. Establishments find ways to address these shortages, by training or seeking out qualified workers.

Small establishments, especially those facing moderate to heavy competition and with little advanced technology, are the ones that face the greatest challenges from skill shortages. These are also the least likely to overcome these challenges.

Firms that overcome the challenges of adopting new technologies, such as the hiring and training of skilled personnel, may be rewarded with increased productivity and higher growth. With growth comes another increase in demand for skilled people to fuel the next cycle of adoption.

References

This article is derived from the Analytical Studies Branch Research Paper No. 175—*Skill Shortages and Impediments to Adoption of Manufacturing Technology*. The paper is available on the Statistics Canada Web site (http://www.statcan.ca) free of charge at Our Products and Services, Research Papers (free), Social Conditions, Analytical Studies Branch research paper series.

Further information: David Sabourin, Senior Research Economist, Micro-Economics Analysis Division, Statistics Canada, (613) 951-3735, sabodav@statcan.ca

Interpreting innovation indicators

"Innovation" can be defined and interpreted in different ways. Some say that if you cannot define something you cannot measure it, and if you cannot measure it, you cannot manage it. Measuring innovation requires definitions and standards. Interpreting the measures requires an understanding of the "system of innovation". Many of Statistics Canada's surveys measure components of the system of innovation. These are tied together conceptually using our **Science and Technology Activities and Impacts** framework. The framework provides the direction when interpreting the results and asking, "Is this important?"

Introduction

Firms innovate in all aspects of their business to gain or sustain competitive advantage. An innovative financing package may be offered to win a contract. New marketing techniques may be adopted to build customer loyalty. Pricing strategies may be changed to attract new customers and increase market share. The command-and-control type managers may be replaced by inspiring leaders to revitalize the company. Measurement of innovation has generally been related to technological advancement, i.e., significant improvements to existing products[1], introduction of new goods or services and the adoption of more efficient methods of production or delivery.

Measurement of knowledge and its commercial applications is not easy, but over time various indicators have come into common usage. These indicators supplement each other; that is, one is not a predictor of the other.

In order to carry an idea from inception to product development and introduction to the market, a firm must bring together many capabilities. Technological competence by itself may not ensure the successful launch of a product or even the development of a product, but it is the principal source of sustainable competitive advantage and essential for global leadership.

The traditional barriers to entry that used to provide captive markets are falling one by one. De-regulation has opened up markets to more competitors. ICTs (information and communications technologies) have reduced the importance of cost of transportation as a determinant of the location of production facilities. Tariff reduction and creation or expansion of trading areas has exposed domestic markets to global competition. Technological competence provides the new strategic barrier firms can create to ensure sustainable competitive advantage.

As knowledge or the technological competence has emerged as the strategic asset of the corporations in the new business environment, the generation and acquisition of knowledge, its management and its commercial applications are the key activities of a modern corporation. Firms learn from experience and through experimentation and, in order to get access to knowledge available elsewhere, they form networks, forge alliances and buy other firms.

The "system of innovation"

Figure 1 presents a simplified system of innovation in which knowledge is the strategic asset. We have organized the main components of the system into inputs, outcomes and impacts in order to present a coherent picture of the relationship between technological change and its impact on the economy. The first column shows indicators of innovation capacity (knowledge base, knowledge generation within the firm, and the various ways in which firms acquire knowledge from external sources). Outcomes are divided into intellectual property that can be licensed for commercial use and new or improved products and processes offered on the market Performance indicators or impacts are given in the last column. For illustrative purposes, Table 1 summarizes the estimated values of these components for the engineering services industry. A more detailed version of this table is available in one of our publications, *Capacity to Innovate, Innovation and Impact* which is available on Statistics Canada's Web site free of charge (under Downloadable research papers–free).

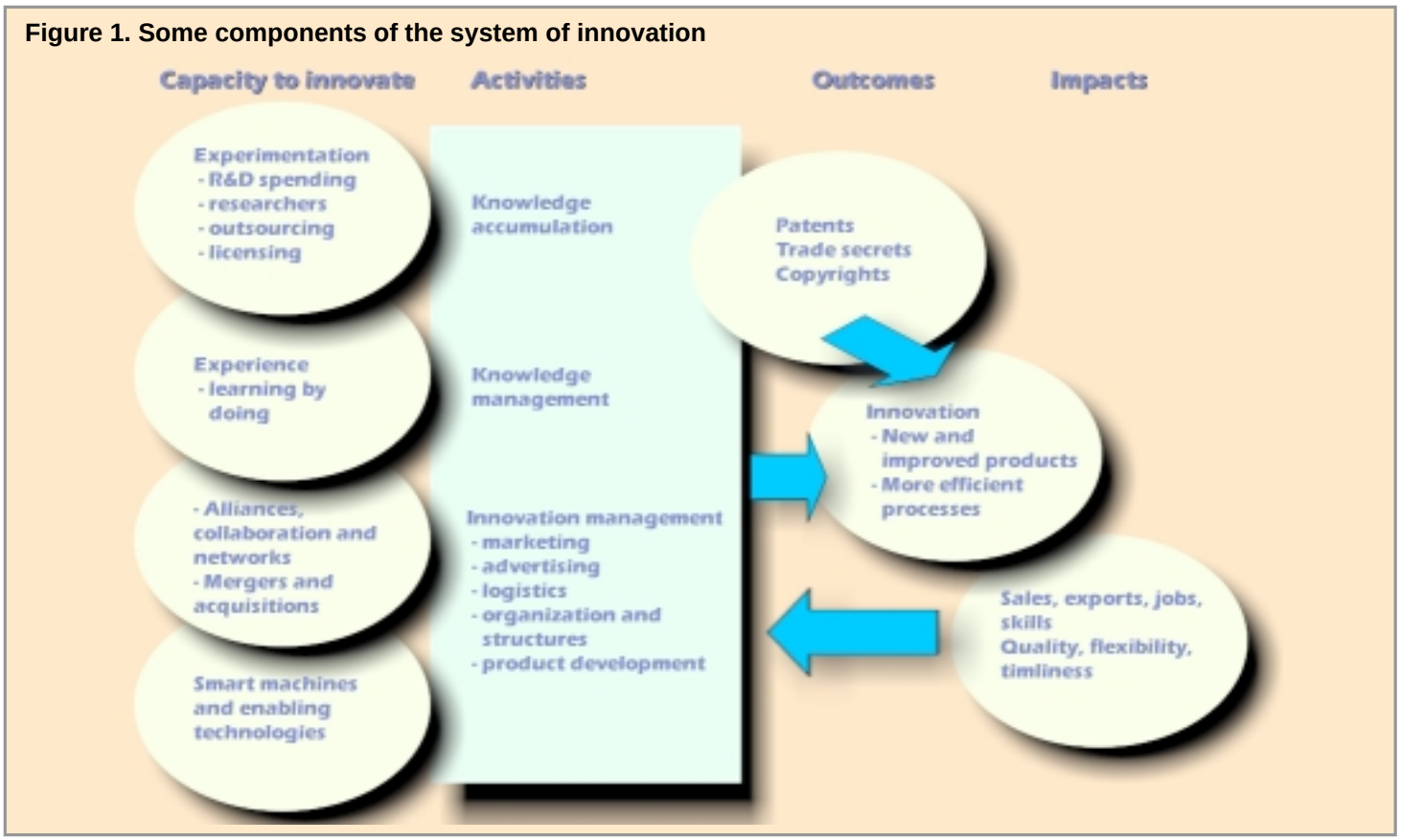
The capacity to innovate

Measurement of knowledge and its commercial applications is not easy, but over time various indicators have come into common usage. Occupation and level of education are often used as proxies for measures of the knowledge base. Other indicators are the levels of on-the-job training and job turnover rates. These indicators supplement each other, that is, one is not a predictor of the other—it is possible to have many university graduates and not as many professional employees. The difference between these two figures gives some indication of the appropriateness of employment.

Of the engineering firms surveyed in 1997, 10% engaged in R&D regularly. Experimentation (R&D) is a useful indicator of investment in innovation potential. Research, by its experimental nature, may not always result in inventions, patents of new products or may take long time to do so, but breakthrough

[1] The term product is used to mean a good or service.

Figure 1. Some components of the system of innovation



innovations are less likely to happen without it. Statistics Canada has been gathering data on this important activity since 1956.

Since, knowledge itself is recognized as the key asset of the corporations, a survey—the first official survey of its kind– is about to go in the field to gather information on the knowledge management practices of corporations.

Outcomes

Forty one per cent of the engineering services firms identified themselves as innovators, but only 4 per cent of them had introduced breakthrough products or processes that had the potential of putting these firms in the role of global leaders.

While 10% of the firms performed R&D, 12% reported using patents and copyrights to protect their intellectual property. Inventions and patents are a step closer to the commercial application of knowledge than R&D. But used alone, the number of patents has shortcomings:

- All inventions are not patentable. They may not meet the criteria of the particular patent rules or someone may have filed a patent on a similar invention the day before.
- Patentable inventions are not all patented. Industries have different propensity to patent and the propensity to patent changes over time. Patenting is a lengthy and often expensive undertaking. Furthermore, many firms prefer to use other forms of protection, such as non-disclosure agreements, or use business strategies to appropriate their investment such as being first to the market.
- All patented inventions are not necessarily converted into commercial products or processes. One reason for this is that many inventions require a significant development time and expense before they are commercialized.
- Counting the number of patents alone ignores the vast disparity in their commercial values. Some licenses on these patents generate millions of dollars in royalties while others may generate none.

Knowing the number of patents, the number that are licensed and the value of the royalties on licenses derived from the patents give an indication of the economic efficiency of the system of innovation.

Innovation, defined as the first commercial use of an idea, is the closest indicator of the commercial applications of knowledge assets. Statistics on this activity is of relatively recent origin. In addition to providing counts of the innovating firms, surveys of innovation also provide estimates of the impact of new or substantially improved products on sales, exports, jobs and skills. They contain a wealth of data on the links among public and private institutions as well as among the various players in the value chain of a firm.

Many firms innovate even though they do no R&D. They either benefit from the spillovers of other firms' research or obtain ideas

Table A. Components of the system of innovation in the engineering services industry (1997)

Capacity to innovate	Outcomes	Impacts
The knowledge base	**Intellectual property**	
• Professionals (% of workers) 55.7%	• Firms patenting or copyrighting.....12.3%	• Contribution of innovations to (% of all firms):
• Professional employees with:	• Firms using trade secrets.....8.8%	• sales.....16.4%
• doctorate degrees.....5.0%	**Products and processes**	• exports 20.0%
• master's degrees 24.0%	• Innovative firms.....40.7%	• Innovative firms that have (% of innovative firms):
• Firms with training programmes.....11.3%	• Firms having introduced new or improved products.....30.2%	• increased employment 32.4%
Knowledge generation	• Firms having introduced more efficient processes 26.2%	• no change in employment 63.5%
• R&D expenditures as a % of contribution to GDP 8.4%	• Firms having introduced organizational change.....15.6%	• Innovative firms experiencing (% of innovative firms):
• Propensity to perform R&D regularly 10.2%	• Innovation rate of:	• improvement in skill levels.....37.4%
• Firms engaged in R&D alliances.....13.7%	• Exporters 73.0%	• no change in skill levels.....60.5%
Knowledge acquisition	• Non-exporters 32.3%	• Innovative firms reporting increased flexibility in meeting client needs (% of innovators).....53.4%
• Firms collaborating on R&D with universities.....3.5%	• Internet users.....76.6%	• Innovating firms that experienced improvement in timeliness of service (% of innovating firms)…… 43.4%
• Firms with collaborative innovation projects 10.6%	• R&D performers.....98.1%	
• Firms acquiring right to use intellectual property from domestic firms.....5.8%	• Newly acquired firms 60.8%	
• Firms using Internet technology.....62.3%	• Novelty of innovation	
	• Breakthroughs 3.8%	
	• New line of products 15.0%	
	• New product.....28.1%	
	• Improvement or cost-reduction 53.2%	

from their clients and suppliers. Innovations differ with respect to novelty. For example, 41 per cent of the engineering services firms identified themselves as innovators, but most of them introduced products that were duplications or replications of the existing products with some modification. Only 4 per cent of them had introduced breakthrough products or processes that had the potential of putting these firms in the role of global leaders. Exporters, Internet users and R&D performers vastly outperformed the rest.

Some innovations are crucial and become enabling technologies for other innovations such as information and communication technologies and biotechnology. Statistics Canada has been conducting surveys of these various technologies since 1996.

Impacts

One of the most direct measures of the impact of innovation is the proportion of sales and exports attributable to the new products and processes. In 1994-96, innovations contributed 16% of the sales and 20% of the exports of the engineering services industry. There are, in addition, qualitative indicators. For example, 53% of the innovators reported significant improvement in flexibility in meeting client needs, and 43% noted improvement in the timing of the delivery of services.

The impact of innovation on employment depends on the type of innovation. Product innovation results in more jobs while process innovation may reduce jobs by increasing productivity. The net effect, however, is more jobs. About 32% of the firms reported an increase in employment and 64% reported no change. Only 4% experienced a decline.

Similarly, the effect on skills is a function of the novelty of innovation and the educational levels of the workforce. On balance, however, innovation results in upgrading of skills, with 37% of the innovators reporting an improvement. There was no change for 60% of the innovators.

Summary

Innovation is a complex process. Individual indicators provide useful insights into the specific components. Together, they provide an understanding of the linkages and the process by which knowledge assets are converted into commercial applications.

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

Daood.Hamdani@statcan.ca

or

Michael Bordt, Chief, Human Resources and Intellectual Property, SIEID, Statistics Canada, (613) 951-8585, Michael.Bordt@statcan.ca

Survey of Knowledge Management Practices, 2001

Knowledge management, whether explicitly conducted by an organization or embedded in its routines, is an important strategy that makes the best use of available knowledge for the benefit of the organization. Until now, there have been no official statistics on these practices that support acquiring, sharing, transferring and retaining this key asset.

There is still much lively debate about the exact definition of *knowledge management* but there are some areas of agreement: it is not data management and it is more than information management. In its purest sense, it is placing value on the experience and know-how of the members of an organization.

> *Knowledge is a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers. In organizations, it often becomes embedded not only in documents or repositories but also in organizational routines, practices and norms.*
>
> Thomas H. Davenport and Larry Prusak, 1998, *Working Knowledge*, Harvard Business School Press, Boston, Massachusetts

Statistics Canada is conducting a pilot survey on Knowledge Management Practices beginning in September 2001. The primary objectives are to determine what business practices are used to support the sharing, transfer, acquisition and retention of knowledge by Canadian firms and whether the firms find these practices effective. The survey identifies the use and planned-use of a series of business practices related to knowledge management. These practices are grouped into policies and strategies; leadership; incentives; knowledge capture and acquisition; training and mentoring; and communications.

The survey is part of an international initiative headed by the Organisation for Economic Co-operation and Development (OECD). Canada is the lead country piloting this survey. Other OECD countries will run similar surveys shortly. Results of the Statistics Canada survey are expected by March 2002.

The questionnaire is available on the Statistics Canada Web site See page 2 for instructions on finding and downloading sample questionnaires.

Further information: Louise Earl, Head, Knowledge Management Unit, SIEID, Statistics Canada, (613) 951-2880, Louise.Earl@statcan.ca

The cable industry – An industry in transition

For many years, the cable industry comprised territorial monopolies providing their customers with basic television programming services in a regulated environment. This situation has considerably evolved in the last few years.

The introduction of many new specialty and pay channels in the 90s has given the industry new sources of revenues and has considerably changed its cost structure. The recent opening of the program distribution market to competition from satellite and multipoint distribution operators (wireless operators), the entry of the industry into the high speed Internet access service market and the deployment of digital television also represented fundamental changes for the industry. The impact of those changes is becoming more and more visible.

Wireless operators are gaining market share

The number of subscribers to audiovisual programming services reached 8.9 million on August 31, 2000, an increase of 4.3% over 1999. Of these, more than 7.9 million were clients of cable operators and close to 1 million were clients of wireless operators. The market share of wireless operators jumped to 10.8% in 2000 from 2.8% two years earlier.

Market share by type of supplier

	% of subscribers		
	1998	1999	2000
Cable	97.2	93.5	89.2
Wireless	2.8	6.5	10.8

The number of subscribers of cable companies decreased in 2000, a first in the industry's history. The competition from wireless operators had the greatest impact on small and medium size cable operators. Close to 60.0% of them sustained a drop in subscriptions and, as a group, they had a net lost of 84,400 subscribers in 2000, and of 202,000 over the 1998-2000 period. Large cable systems fared better with an increase of 42,600 sub-

scribers in 2000. Two-thirds of large systems added to their customer base.

The decline in number of subscribers to cable services occurred in all provinces except Quebec, where the situation remained essentially unchanged from 1999.

Important difference between the financial performance of entrant and incumbent firms

New firms entering an established industry generally operate a few years before reaching profitability. This phenomenon was observed when the long distance telephone market was opened to competition. History is repeating itself in the case of program distribution. Despite very strong growth in its subscriptions (75%) and revenues (128%) in 2000, the wireless segment of the industry has not yet attained profitability. The very high promotion and technical expenses - close to $400 per subscriber in 2000 - incurred to attract and connect new customers largely explains this situation.

Profit margin by type of supplier (before interest and taxes)

	1998	1999	2000
Cable	23.7	21.7	19.3
Wireless	-349.2	-140.4	-98.5

Incumbent firms seem to have adjusted well to the new competitive environment. Cable operators' profit margin (before interest and taxes) remained comparatively high in 2000 at 19.3%, although lower than in the two previous years. The 2000 profit margins surpassed those realized during the same period by conventional private broadcasters, pay and specialty undertakings and telecommunications services providers. Revenue growth was also strong at 8.6%. Much of this growth is attributable to the 19.9% increase in revenues from the provision of discretionary programming services and non-programming services. These sources of revenues accounted for 43.0% of the industry's revenues in 2000 compared to 39.0% in 1999. The growing popularity of high-speed cable modem service is in part responsible for this shift in sources of revenues. The provision of this service generated $275 million for cable companies and their affiliates in 2000.

High speed Internet access by cable and digital television are two fast growing markets

High speed Internet access services by cable attracted 422,300 new customers to the cable industry between September 1, 1999 and August 31, 2000, an average of just over 35,000 new customers every month. At the end of August 2000, there were 786,300 subscribers to this service, compared to 364,000 a year earlier. This very rapid growth continued in the later part of 2000 and the number of subscribers surpassed the 1 million mark in early 2001 (see Household Internet Use Survey, Daily, July 26, 2001). The growth in subscriptions to this service was strong in all regions of the country.

High speed Internet access by cable

Subscribers by region, August 31, 2000		
Province/Region	1999	2000
	thousands	
Atlantic	11.0	23.0
Quebec	55.0	119.1
Ontario	142.0	305.2
Prairies	85.0	117.8
British Columbia and Territories	71.0	161.2
Canada	**364.0**	**786.3**

Approximately 2.7 million new households gained access to high speed Internet services by cable in 2000. Despite the fact that these services were launched by cable operators as recently as November 1996, 7.5 million households, or 68.2% of all households passed by cable, could subscribe to cable modem service at the end of August 2000 if they wished to do so. Within the geographical areas served by operators offering cable modem service, this proportion reached 86.1%.

The market penetration of high speed Internet access by cable, expressed in terms of households with access to such services, reached 10.5% in 2000, up from 7.6% in 1999. Market penetration was highest in the Prairie Provinces and in British Columbia and lowest in Quebec and the Atlantic Provinces. The provision of cable modem service largely remained the domain of the top 5 firms in the industry. In 2000, they served 93.3% of all subscribers to these services, up from 92.6% in 1999.

High speed Internet access by cable

Penetration (%) at August 31, 2000		
	1999	2000
Atlantic	..	8.8
Quebec	..	6.4
Ontario	..	10.9
Prairies	..	13.6
British Columbia and Territories	..	12.7
Canada	**7.6**	**10.5**

The penetration of the digital technology is also gaining momentum. This technology allows, or will allow, cable and wireless broadcast distribution undertakings to offer a range of interactive services such as interactive program guides, television-based Web access and interactive television. At August 31, 2000, cable operators had deployed 390,800 digital terminals and wireless operators had deployed 967,800. In total, 15.2% of subscribers to programming services have adopted the digital technology.

A favourable environment for investments and employment creation

Substantial investments were necessary to upgrade the existing cable infrastructure in order to offer cable modem and digital

Additions to fixed assets ($000,000) by type of supplier

	1998	1999	2000
Cable	774.1	1,110.8	1,523.3
Wireless	30.6	194.1	158.1

Number of employees by type of supplier

Type of supplier	1998	1999	2000
	(weekly average)		
Cable	9,105	10,947	12,176
Wireless	367	1,249	1,929
Total	**9,472**	**12,196**	**14,105**

television services. The cable industry has invested a total of $3.4 billion over the 1998-2000 period, or close to $310 per home passed by cable. Much of this investment ($2.8 billion or $348 per home passed by cable) went into systems that are now offering both cable modem and digital cable services. During that period, wireless operators invested close to $348 million.

The entry of new wireless operators in the industry and the provision of new services by cable operators have led to higher levels of employment. The average weekly number of employees for the industry went from 9,472 in 1998 to 14,105 in 2000.

Detailed data are published in the service bulletin *Broadcasting and Telecommunications*, Vol. 31, No. 3 (56-001-XIE, $10/$32).

Further information: Daniel April, Science, Innovation and Electronic Information Division; (613) 951-3177, Daniel.April@statcan.ca

Use of biotechnologies by Canadian biotechnology firms

According to data released from the Biotechnology Use and Development Survey -1999, Canada had 358 biotechnology firms that generated revenues of more than $1.9 billion from activities directly related to biotechnology. The survey, administered by the Science, Innovation and Electronic Information Division of Statistics Canada, provides information on firms involved in developing new products and processes using biotechnologies. It was conducted as part of a project to develop biotechnology statistics under the Canadian Biotechnology Strategy. It addressed the basic question: What are the characteristics and activities of firms that use or develop biotechnology as an important part of their firms' activities? This article looks at the use of biotechnology, the benefits of using biotechnology, obstacles to commercialization and information sources on biotechnology.

Current use of biotechnologies

Firms provided information on their current use of biotechnologies, the purpose of using biotechnology, number of years using the biotechnology, and, if they were not using a particular biotechnology, if they planned to use that biotechnology within the next 3 years. There are four major categories; DNA based; Biochemistry/Immunochemistry; Bioprocessing based; and Environment biotechnologies made up of 17 different biotechnologies. Average time of use of biotechnologies varies ranging from 3 years to almost 11 years. Research and development is the most common activity, not surprising given that the majority of respondents are R&D intensive firms.

There were a total of 423 instances of firms[2] using DNA based biotechnologies, with research and development (R&D) the primary use, reported in 416 cases. This far outstripped their use in current production. With an average use of 4 years, DNA based biotechnologies is the youngest of the different sectors. The Genetic engineering/DNA sequencing sub-grouping was the most popular biotechnology with 140 firms reporting its use primarily for R&D. Growth in the use of these biotechnologies is anticipated, with 151 new users of DNA based biotechnologies expected within the next 3 years.

The eight biotechnologies found in Biochemistry/immunochemistry section were the most frequently utilized biotechnologies with a cumulative 795 occurrences, mainly for R&D purposes (700), but also for production (243) and environmental (78) purposes. Average time of use had the greatest range from 4.2 years to 10.6 years. The microbiology/virology/microbial/ecology sub-group was reported as currently used by 171 firms for R&D, production and environmental purposes averaging 10.6 years in use. This was one of the longest average periods a biotechnology was used.

Bioprocessing based biotechnologies have been used for the longest period with an average period of 8.5 years. This may reflect its maturity, and it may have, as a group, shifted from an R&D focus to a more standardized process. Only 35 more firms plan to introduce these technologies in the next 3 years. The final category is the environmental biotechnologies, where again the focus is on R&D, but with a significant number of firms reporting using these techniques in current production stage.

Benefits of biotechnologies

Firms reported a wide range of benefits derived from using biotechnologies. According to 96% of the respondents biotechnology is used first to develop new products or processes. Further, 90% of the respondents reported that improvement in product quality was important or highly important. Lower capital cost was rated with low importance as a benefit by over a quarter of the respondents. Generally product improvement related bene-

[2] Firms provided multiple responses to biotechnologies used. These are the results for the 358 core biotech firms.

fits were rated as important benefits of using biotechnology while reduced costs were of low importance as benefits. Improving market position was also rated highly by firms as an important benefit for using biotechnologies.

Obstacles to biotechnology commercialization

As firms race to commercialize products they face a myriad of obstacles ranging from the regulatory system to financial concerns and marketing issues. Access to capital and time/cost constraints were seen as the most significant obstacles to the commercialization of biotechnology. Patent protection issues were rated as not significant impediments to commercialization by at least 62% of respondents. Patent rights held by others were rated as an important obstacle by over 30% of respondents. Interestingly, public perception of biotechnology was given low importance by over a third of respondent and not applicable by a further 23% of respondents.

Information sources on biotechnology

As the technology is relatively new, firms must seek and exchange information using a wide variety of sources to obtain information on biotechnology. Among the most highly rated options were Universities/Colleges and personal contact as well as conferences and workshops. These highlight the continued importance of tacit knowledge that can often times be exchanged only through personal contact. In addition, 98% of the firms used the Internet, for such diverse purposes as accessing databases and information sources (85%) to marketing and selling purposes (53%) to sharing R&D (44%). It is interesting to note that less than 20% of respondents relied on the Internet for e-commerce purposes. Firms were least likely to use government sources for information on biotechnology.

Summary

Firms experienced a number of different benefits from using biotechnologies ranging from DNA based to environmental biotechnologies. However given the fact that the core firms are research and development oriented, it is no surprise to see the main use and benefit is research and development.

References

Additional detail can be found in the Working Paper: *Practices & Activities of Canadian Biotechnology Firms* available at www.statcan.ca.

McNiven, Chuck (2001) *Biotechnology Use & Development Survey – 1999*. SIEID Working Paper Series, Statistics Canada.

McNiven, Chuck (2001) *Practices and Activities of Biotechnology Firms: Results from the Biotechnology Use & Development Survey – 1999*. SIEID Working Paper Series, Statistics Canada.

Further information: Chuck McNiven, Life Sciences Unit, SIEID, Statistics Canada, (613) 951-1233, Chuck.McNiven@statcan.ca

Selected strategies and practices of Canadian biotechnology firms: Results from the Biotechnology Use and Development Survey – 1999

Canada had 358 biotechnology firms in 1999 generating revenues of more than $1.9 billion from activities directly related to biotechnology, according to data from the Biotechnology Use and Development Survey -1999. This article gives an overview of some of the business strategies and practices used by biotechnology firms in order to conduct research and development and for some, commercialization of their products.

Business relationships

During the development of products involving biotechnology, firms[3] face multiple challenges. Each of these challenges requires specific competencies/capacities that may or may not exist within the firm. One option is to form alliances with others. The type of partner or style of partnership may vary with the particular challenge faced. For example in the early stages of product development, firms may seek technical help though alliances with universities or research facilities. At the latter stage of development regulatory approval requires extensive specialized knowledge and funding. This was the reason for 6% of the alliances. At the commercialization stage firms may be looking for product distribution channels. Firms may also seek an alliance as a method to reduce the expense and risk associated with efforts to solve problems or to further advance R&D. Biotech firms entered into collaborative arrangements for R&D purposes 33% of the time.

Based on evidence from the survey, alliances appear to form part of the network of relationships in business. Participants in alliances come from business, academia and government sectors in almost any combination. Relationships can be vertical, as between vendor and customer, or horizontal, as between vendors. They occur on local or global scales or both, and can even occur between competitors. In 1999, firms entered into 194 agreements with universities/hospitals, 107 agreements with government departments/agencies and 336 collaborative arrangements with other businesses, smaller and larger. Biotechnology firms entered

[3] Biotechnology firms are defined as those firms conducting active research and development in biotechnology and consider biotechnology central to their activities. These firms are referred to as biotechnology firms or core firms throughout the paper.

The number of employees the firm has identifies firm size. Small firms are those with 50 or less employees; medium sized firms have 51- 150 employees; and large firms are comprised of 151 or more employees.

into a total of 694 co-operative arrangements[4]. A total of 59% of those arrangements were entered into by 168 of the 270 small firms. As well, 28 of the 37 large firms had 23% of the arrangements. By far the majority of arrangements were found in the human health sector, with 114 out of 150 human health firms reporting 369 arrangements, more than 3 times as many arrangements as agriculture firms, with 110 arrangements.

Raising capital

Capital is essential to the biotechnology industry. Firms face long and expensive research and development programs and often lengthy approval processes, all prior to proving the commercial viability of a product. Firms search among a variety of sources for capital, ranging from conventional sources such as banks to friends and relatives of firm owners, to venture capital funds. The need for new capital varies according to the field of research, the stage of development and the past success in raising capital. Access to capital was also rated by core firms as a prime obstacle to commercialization of biotechnology.

About 50% of biotechnology firms (178) attempted to raise capital in 1999, with a success rate of 78%. They raised over $2 billion in capital, an average of $16 million per firm. The human health sector led with 81% of 104 firms attempting to raise capital, successfully raising $866 million. The most common capital source was venture capital funds with nearly a third of firms obtaining venture capital funding. The second most common source of capital was angel investors/family/friends, with over 25% obtaining funding from this source. Conventional sources provided just 7% of capital to small firms. In comparison, large firms raised 22% of their capital from conventional sources. Initial public offerings and collaborative alliances were unique techniques to the medium sized group for raising capital. Activity in the capital markets is expected to increase in 2002 when 206 firms plan to attempt to raise capital, compared to 178 in 1999. Most firms (48%) plan to raise over $5 million in capital in 2002, while 37% plan to raise between $500,000 and $5 million.

Contracting out

Biotechnology firms were very active in contracting out activities. Firms contracted out almost $1 billion for a variety of purposes. By far the most common purpose (187 firms) was contracts for research and development purposes, valued at $858 million. This exceeded the value firms spent internally on research and development. Firms (85) contracted out over $100 million on regulatory and clinical matters and lesser amounts for marketing and management purposes. Firms in Quebec were the most active in contracting activity, contracting over 70% of the research and development contracts. The human health sector contracted almost $400 million in research and development contracts and accounted for 98% of the regulatory and clinical affairs contracts.

Patents

Patents are important to biotechnology firms in order to protect their intellectual properties. Patents create a visible, tangible asset that can then be traded or used as guarantees for investors or to generate revenues. Patents are useful indicators of developments in the biotechnology sector. Canadian biotechnology firms held nearly 8000 pending and existing patents world-wide in 1999. They were split between 3,706 existing patents and 4,259 pending patents. Nearly 75% of biotech firms are small, but they held 34% of patents. Large firms held over half of pending and existing patents. Over a two-year period firms submitted a total of 2266 applications to domestic and foreign patent offices (51% in 1998 and 49% in 1999). The majority, 36%, of these patents was submitted to the United States Patent & Trademark Office, followed by 28% to the Canadian Intellectual Property Office, 21% to the European Patent Office, and the balance of 16% to patent offices elsewhere in the world.

Exchange of intellectual property

The commercialization of intellectual property (IP) is a primary way for firms to profit from their research. Licensing can bring immediate financial gain and require less of an investment in time and capital by the licensee. However, the benefits are generally more limited in terms of length of agreements and amounts returned to the licensee. Firms provided information on the exchange of intellectual property, from both the IP acquiring and IP granting perspective. Overall, 79 firms acquired 109 intellectual property rights from other firms. Rights were acquired from Canadian firms 45% of the time. About 38% of firms acquired rights from both Canadian and foreign firms.

Intellectual property can be commercialized through the creation of spin-off companies. The reasons for the spin-off can range from the need for streamlining operations to marketing control to the desire to allow the spin-off operation to operate freely. Reasons to spin-off companies can vary based on the between types of institutions holding the rights to potentially commercial developments. Results from the survey indicate there were 123 spin-off firms among the 358 biotechnology firms in Canada in 1999. The majority (86%) of these firms was spun off from the university/hospital sector and most (91%) are found in the small firm category.

Summary

Firms utilized numerous strategies and practices to survive in the highly competitive and challenging biotechnology sector. This paper examined some of those strategies and practices. Biotechnology firms are generally flexible and innovative in their approaches to survival and growth in Canada and also on the world stage.

References

McNiven, Chuck (2001) Biotechnology Use & Development Survey – 1999. Working Paper Series. Statistics Canada.

McNiven, Chuck (2001) Practices and Activities of Biotechnology Firms: Results from the Biotechnology Use & Development Survey – 1999. Working Paper Series. Statistics Canada.

Further information: Chuck McNiven, Life Sciences Unit, SIEID, Statistics Canada, (613) 951-1233, Chuck.McNiven@statcan.ca

[4] Some respondents reported more than 1 agreement.

Canadian biotech firms: Extent of networking activities and commercialization obstacles

Recent Statistics Canada estimates based on the 1997 **Biotechnology Firm Survey** provide information on the biotechnology firms. These firms generated $813 million in biotech revenues; employed 9,000 people in biotech related activities and had 8,924 products across all stages of development. What are the main features of Canadian biotechnology? What is the extent of networking activities by the firms? And what kinds of problems are they facing when selling their products? These questions are explored in the following article.

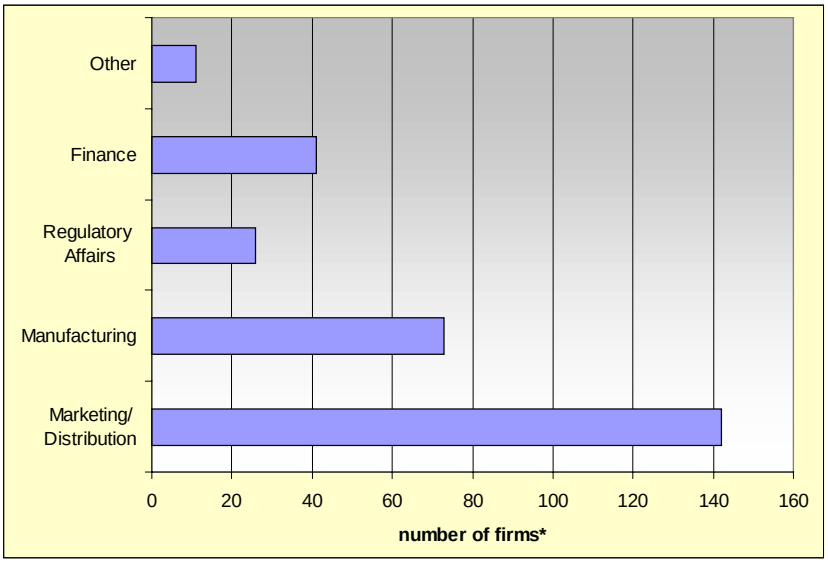
Features of Canadian biotech activities

As of 1997, the core of Canadian biotechnology industrial activities was performed within 282 firms. Of these, 76% were small firms with less than 50 employees, 13% were medium-sized with 51 to 150 employees, and 11% were large firms with over 150 employees. The majority of the biotech firms (48%) were in the health sector. Combined, Quebec and Ontario were home to 59% of core firms. They brought in $14 billion in total revenues. Of these, $813 million came from biotech sales. In total, they exported for over $3 billion in products. Nine percent of that amount, i.e. $311 million were from biotech products and processes exports. They spent $926 million in R&D. Of these, 53% went to R&D in biotech, with firms in Quebec and Ontario outspending firms from other provinces. The total number of products at all stages of development was 8,924. Twenty percent of that number represented products approved or on the markets - 41% were products in clinical/field trial and 39% were under development. Nine thousand people out of a total of 32,000 were working in biotechnology. The main hurdle to biotech commercialization is access to capital. Thirty nine percent of biotech firms raised financing capital in the 1997 year. For that, they heavily rely on private placements, venture capital, and labour sponsored funds. Networking is an important activity of biotech firms, with marketing and distribution being the major reason for the establishment of such alliances. Over half of the biotech firms entertained R&D partnerships with universities.

Networking activities: strategic alliances and R&D partnerships

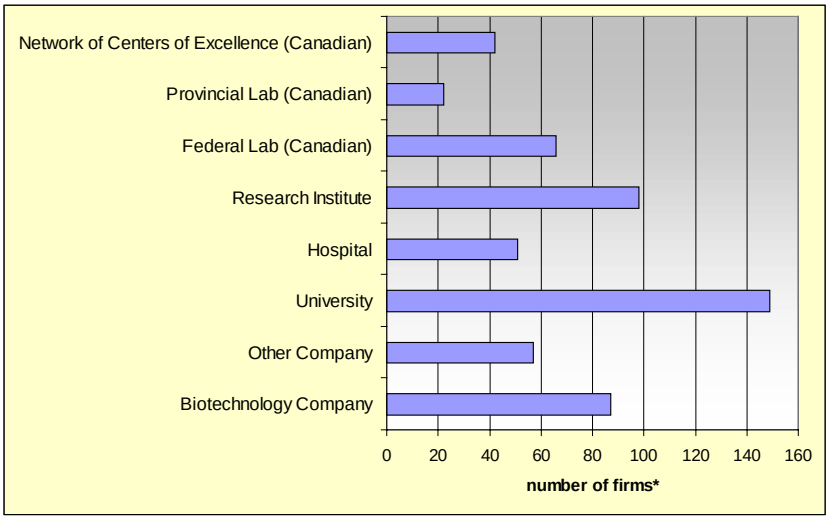
Marketing and distribution constitute the major reasons for entering strategic alliances: half of the biotechnology firms had such agreements in 1997. Manufacturing was the reason to enter an alliance for 73 or over a quarter of biotech firms, while financial reasons helped create 41 alliances,

Chart 1: Purposes for entering strategic alliances



Source: Statistics Canada
* The total number of firms is more than 282 because some firms have multiple partners in multiple locations.

Chart 2: R&D partnerships undertaken by Canadian biotech firms

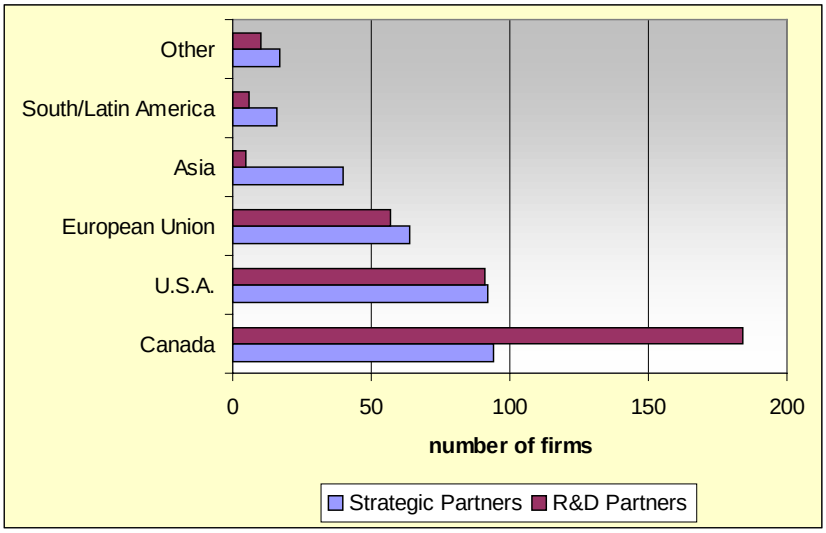


Source: Statistics Canada
* The total number of firms is more than 282 because some firms have multiple partners in multiple locations

and regulatory purposes, 26. Other reasons caused 11 biotech firms to enter into strategic alliances.

As for R&D partnerships, universities constitute a very popular R&D partner for Canadian biotech firms. In 1997, 149 or over half of the firms entertained R&D partnerships with these institutions. Research Institutes and other biotechnology companies were partners with 98 and 87 biotech firms, respectively. Other R&D partners included Canadian federal laboratories which had partnership relations with 66 firms, other companies had 57 biotech firms as partners, 51 were partners with hospitals and 42 entertained partnerships with the Canadian network of centres of excellence. Canadian provincial laboratories were partners with 22 of biotech firms.

Chart 3: Origins of strategic and R&D partners



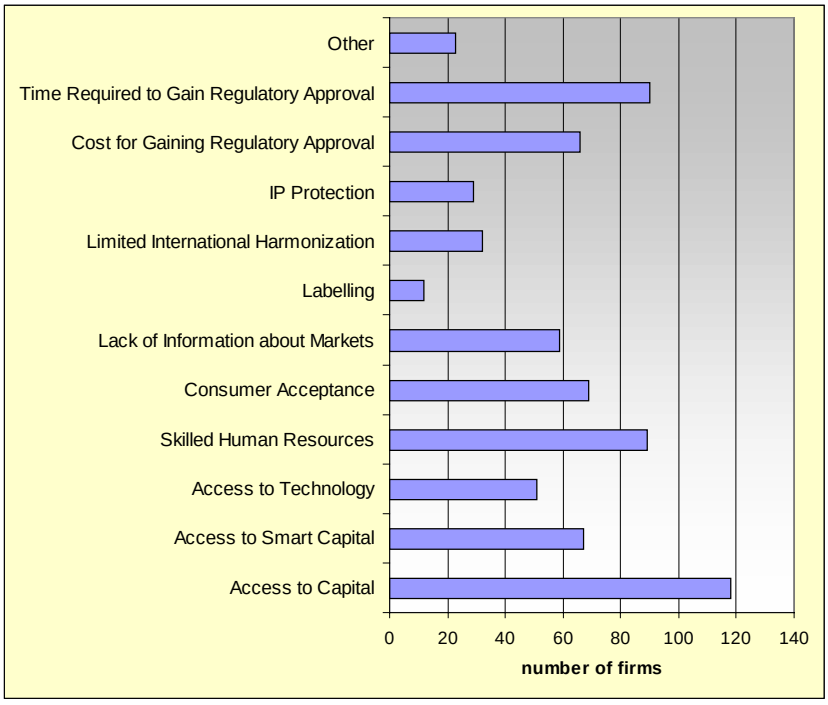
Source: Statistics Canada.

Origins of strategic alliances and R&D partners

Canada and the USA are equally important to the biotechnology firms in entering strategic alliances: 94 firms had Canadian partners and 92 had American partners. Sixty-four had partners in the European Union, and 40 had strategic partners in Asia. Sixteen firms had South/Latin American strategic partnerships.

As for R&D partners, Canada is by far where most of the partners of firms are found: 184 or over 65% of them had R&D partners in Canada. The U.S.A. came second with 91 firms having American partners against 57 who had partners in countries of the European community. Asia and South/Latin America totalled 11 partnerships.

Chart 4: Main commercialization problems facing Canadian biotech firms



Source: Statistics Canada.

Main biotechnology commercialization obstacles

Access to capital is a major obstacle to commercializing biotechnology in Canada. In fact, 118 of the 282 biotechnology firms, i.e. 42%, faced this problem in 1997. Access to skilled human resources and the time requirements for gaining regulatory approval are also important issues confronting Canadian biotech firms. These issues affected 32% of them. Consumer acceptance, higher costs for gaining regulatory approval, the access to technology, and the lack of information about markets are other important obstacles faced by biotech firms in selling their products. Intellectual property (IP) protection, limited international harmonization and labelling were a concern to very few of firms in 1997.

References

This article draws on the SIEID working paper: *Canadian biotechnology industrial activities: Features from the 1997 Biotechnology Survey* released in September 2001.

Further information: Namatié Traoré, SIEID, Statistics Canada, (613) 951-4489, Namatie.Traore@statcan.ca

What's new?

Recent and upcoming events in innovation analysis.

Connectedness

In August, the fourth issue of the Connected Series: *Internet use among older Canadians* (56F0004MIE, free) was released. According to the report, authored by Statistics Canada's Housing, family and social statistics division, Canadians over the age of 60 are about one-fifth as likely to be using the Internet as their younger counterparts.

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

Telecommunications

Annual survey of telecommunications service providers

Status: Annual survey 2000 is in the field. The 1999 Annual data was released in August. The Annual bulletin will be released in October.

Quarterly survey of telecommunications service providers

Status: First quarter results were released in September. The second quarter results are scheduled for release in October.

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

Broadcasting

Status: The annual report *Radio and television broadcasting, 1999* (Cat. No. 56-204-XIB) was released in May. Preliminary data for the 2000 reference year were released for private radio broadcasters, private television broadcasters and the cable industry in July. These reports appear in the *Broadcasting and telecommunications service bulletin*, (Cat. No. 56-001-XIE) Vol. 31, Nos. 1, 2 and 3.

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

Household Internet use

Status: Analysis based on the *Household Internet use survey, 2000* was released in July. See the Statistics Canada Daily issue of July 26, 2001. The public-use microdata file from this survey is now available on CD-ROM (Cat. No. 56M0002XCB, $2,000).

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

Business e-commerce

Survey of electronic commerce and technology

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

Science and innovation

S&T activities

Research and development in Canada

Status: Statistics on *R&D Personnel in Canada* were released in May in *Science statistics* Vol. 25, No. 5 (Cat. No. 88-001-XIB).

Federal and provincial S&T

Federal science expenditures

Status:

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

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

Industrial R&D

Research and development in Canadian industry

Status: Preliminary Industry R&D spending figures for 2000 and intentions for 2001 were released in July in *Science statistics*, Vol. 25, No. 6 (Cat. No. 88-001-XIB).

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

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

The annual report 88-202 *Industrial Research & Development 2001 Intentions* will be released in October 2001

Research and development in the health field

Status:

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

Human resources and intellectual property

The higher education sector

Intellectual property commercialization in the higher education sector

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

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

Federal intellectual property management

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

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

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

Advanced technologies

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

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

Advanced technologies in natural resource industries

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

Innovation

Innovation in manufacturing

Status: The working paper *Innovation in Canadian manufacturing: National estimates* (Cat. No. 88F0006XIB01010, free) was released in June (see the June 27 issue of The Daily). The first in a series of analytical results from the *1999 Survey of Innovation* examines the characteristics of innovative firms in manufacturing.

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

Innovation in services

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

Biotechnology

Federal S&T expenditures

Status: Data from the 2000 survey (*Biotechnology scientific activities in selected federal government departments and agencies 1999-2000*) were released in May in *Science statistics* (Cat. No. 88-001-XIB) Vol. 25, No. 3.

Biotechnology R&D in Canadian industry

Status: Results of the analysis of biotechnology R&D in Canadian industry were released in May in *Science statistics*, Vol. 25, No 4 (Cat. No. 88-001-XIB).

Biotechnology use and development survey - 1999

Status: A working paper *Practices and activities of Canadian biotechnology firms: results from the Biotechnology Use and Development Survey - 1999* (Cat. No. 88F0006XIB01011, free) was released in August. See instructions on page 2 for downloading working papers.

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

Knowledge management practices

Survey of knowledge management practices, 2001

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

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